KUL-BUL

SPIRIT OF SEA COUNTRY

Kul-bul Decision Tree Manual

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Introduction

The Great Barrier Reef is a global natural icon utilised by multiple stakeholders and receives nearly two million visitors each year. No wonder this extraordinary large diverse coral reef system is part of the psyche of most human beings. In the age of anthropogenic climate change, now more than never, feel connected to the Great Barrier Reef. The call to action to do more to conserve and promote this natural wonder resonates strongly.

The first nations people of Australia are the first custodians of the Great Barrier Reef with a physical and spiritual connection that has lasted tens of thousands of years. Since colonisation this connection has been disrupted drastically and left emotional scarring. In recognition of this disruption, we have seen increasing efforts from all Australians in recent decades towards reconciliation and inclusion of First Nations Traditional Owners/Custodians to manage their Country. What has become more apparent in recent years and not to be underestimated, is the wealth of knowledge the First Nations Traditional Owners/Custodians of the Great Barrier Reef possess, that will be crucial to the future protection and management of this World Heritage Icon.

Yet one most notable consideration is how to include First Nation Traditional Owner/Custodian knowledge of Country and management that is culturally sensitive and thoroughly inclusive of our First Nations people. The Kul-bul Decision Tree was developed to recognise and include First Nations Traditional Owner/Custodian Culture in how we work on a coral reef within the Great Barrier Reef.

Contemporary science and First Nations Traditional Owner/Custodian Ecological knowledge share the common principal of repeated observations and testing to determine patterns in the natural world. Following the Decision Tree outlines a practical proactive step by step process to recognise the First Nations Traditional Owners/Custodians of a specific coral reef and lay the framework to build a long-lasting partnership to care for Sea County. Bringing together cultural and biological knowledge of a coral reef can help determine if action is necessary in the form of site assisted recovery actions.

The project backstory

The overall objective of this project was to create a collaborative framework between stakeholders and First Nations Traditional Owners/Custodians. This created a two-way sharing of knowledge and skill development through early consultation, agreements and ongoing engagement and inclusion. The Kul-bul project was co-designed and co-managed with Traditional Owners/custodians, the Yirrganydji people.

The name Kul-bul was selected to name this project, as it was an Yirrganydji word from the Yirrgay dialect that translates to the "Spirit of Sea Country". The logo designed by Yirrganydji man Tarquin Singleton with a three-prong fishing spear surrounded by coral reef. In this case the three prongs represent the three partners involved, which includes, the Dawul Aboriginal Corporation for the Yirrganydji community, Reef Restoration Foundation and GBR Biology (Reef Unlimited/Experience Co.)

How the Kul-bul Decision Tree works

The Kul-bul Decision Tree is a model that incorporates step by step decisions to identify and bring together the cultural significance, cultural engagement, biological and natural resilience indicators and site stewardship recommendations of a specific coral reef site. It uses the knowledge of several well-known coral reef monitoring programs such as Eye on the Reef and or Reef Check. The Kulbul project also created its own methodology (See appendices) to measure various biological and natural indicators that can be incorporated into existing monitoring programs to add an extra layer of information on coral spawning and recruitment rates.

Through the assessment approach, the Kul-Bul Decision Tree documents coral reef processes to gauge if a coral reef site can likely recover naturally following a disturbance, of if intervention may be necessary. Some intervention or site assisted recovery actions include coral predator control, coral rubble stabilisation, coral nurseries, coral gardening and coral larval reseeding.

This manual presents the Kul-Bul Decision Tree (page 13) that was used to produce site stewardship plans for sites on Hastings, Saxon and Norman Reefs within Yirrganydji Sea Country. Working examples of the Kul-Bul Decision Tree are provided for each coral reef and shows the data used to arrive at the appropriate decision on actions to take in the further conservation and management of these reefs. Instructions, along with the appendices are provided to assist in the use of this proactive tool.

As an example of how First Nation Traditional Owner/Custodian Ecological Knowledge can be included in a combined assessment of a coral reef, a seasonal calendar (see back cover) was designed which incorporates Yirrganydji language. The Calendar illustrates the connections between land and sea. The plants are rough indicators for seasonal changes throughout the year and lines up with marine life. There is always interannual variations between the timing of season and this may result in plants or fruit flowering early or late, which can indicate the presence and behaviour of certain marine animals.

Next steps

We hope that the Kul-Bul Decision Tree is a tool that can be adopted by any First Nations Traditional Owner/Custodian Group along the GBR and by multiple stakeholders including tourism operators, researchers, private industry, non-government, and government organisations. We encourage groups that adopt the Kul-Bul Decision Tree to make it their own. Although the Decision tree was created to deal with an individual reef, having multiple groups working on multiple reefs can achieve scale on holistic reef knowledge and conservation.

How to use the Kul-Bul Decision Tree

The Kul-Bul Decision Tree has been partitioned into five sections: 1) cultural awareness, 2) cultural engagement, 3) biological indicators, 4) natural resilience indicators and 5) site stewardship recommendations. Within these sections a total of 72 questions can be used to summarise knowledge and inform steps to develop site stewardship plan for a reef site, including agreed First Nations Traditional Owner Ecological Knowledge.

Throughout the Kul-Bul Decision Tree, First Nations Traditional Owner/Custodians are referred to as Traditional Owners. The Kul-Bul Decision Tree has been written to support non-Traditional Owners to view the selected reef or site in the light of a recognition, engagement and potential inclusion of Traditional Owners in site stewardship projects.

We have designed the Kul-Bul Decision Tree to start with question 1 in the cultural awareness section and move forward. Each question has a yes or no response, that directs the user to the next question or appropriate action. For example, Question 1 asks "*Who are the Traditional Owners of the selected reef"?* If the answer is not known, the user is directed towards contacting the North Queensland Land Council NQLC, Great Barrier Reef Marine Park Authority Reef Traditional Owner, Great Barrier Reef Foundation Traditional Owner Reef Protection or Queensland Parks and Wildlife Service & Partnerships QPWS&P. All these bodies have some form of engagement with the 70 First Nations Traditional Owners/Custodians of the Great Barrier Reef. The questions of the cultural awareness section aid the user in defining the cultural connection and management of selected reef, which flows into cultural engagement outlining steps towards a working relationship or framework towards co-designed/managed projects with Traditional Owners. This section also outlines protocols to consider for safeguarding Traditional Owner Knowledge.

The two cultural sections of the Kul-Bul Decision Tree flow into biological indicators to create a current summary of reef health at the site. The questions in this section are based on knowledge created from involvement in recognised local scale monitoring programs such as the Great Marine Park Authorities Eye on the Reef Tourism weekly and or Reef Health Impact Surveys EOR. Other programs that deliver similar information is Reef Check Australia RCA. However, if participants are not currently involved in any of these monitoring

methodologies see the Kul-Bul monitoring methodologies (Appendix A) can aid in the collection of the appropriate information to answer questions. The tool also caters for if multiple methodologies are used to answer questions. All the monitoring techniques represented in the Kul-Bul Decision Tree Manual compliment and support one another and can provide a holistic representation of current reef site health.

The biological indicator section introduces threshold values in the questions to determine outcomes. For example, questions 32-35 use the threshold value of greater than 40 colonies. This value is linked to the maximum category in the Eye on the Reef Tourism Weekly surveys for an impact, for example, has there been past evidence of severe storm damage (>40 colonies) at the reef site. We have chosen greater than 40 colonies to signify an impact to lead to other questions to quantify that impact on coral reef habitat.

An important question in the decision tree is question 45 that asks, *"Is the percentage of live coral at the reef site greater than 30%?"* The threshold value of 30% was chosen as there is some speculation in scientific literature that this level is critical for coral accretion to outweigh erosion processes. In other words, this level of live coral is vital for coral reefs to keep growing. The following question 46 asks *"Does the dominant coral group at the site have an axial polyp?"* Corals with axial polyps belong to the family Acroporidae and these corals are some of the most recognisable corals. This includes your elaborate staghorn and plate coral species. Corals from this family are considered fast growing or reef building and are quite often referred to as keystone species, that is they are essential to the maintenance of a coral reef ecosystem.

Answers to questions of biological indicators in the decision tree can lead to either the natural resilience indicator section or site stewardship recommendations. For example, if at your site, there is live coral cover greater than 30% and the dominant coral is plate, the tree will direct you towards natural resilience indicators. The next series of questions will be about if the corals at the site have spawned in the past and in what capacity. These questions along with some recruitment knowledge are valuable in evaluating if the selected site, has the capacity to recover naturally following a disturbance or impact.

However, questions in the biological indicators may lead directly to site stewardship recommendations. This may be due to past evidence from coral predators such as

crown-of-thorns starfish (CoTS) and drupella snails. Further questions will lead to a decision on either implementing coral predator control programs, if not already in place. Questions around coral predator densities also use threshold values such greater than 2 individuals per hectare for CoTS and 200 individuals per hectare for drupella snails. These values were selected as densities greater than these are considered detrimental to live coral cover. Other prior questions that determine benthic categories other than live coral are the dominant habitat, such as live coral rock or coral rubble would be directed towards appropriate site assisted recovery actions.

There are numerous site-assisted recovery actions that can be implemented. The decision tree aids in selecting the most appropriate action. For example, if there are large areas of coral rubble. the decision tree would recommend coral rubble stabilisation such as Mars Assisted Reef Restoration System. Large areas of live coral rock are more suited for coral larvae reseeding and or coral nursery and out-planting techniques. On the GBR the most utilised nursery techniques are Reef Restoration Foundation or the Coral Nurture Program. Both these programmes involve out-planting using coral clip. Important questions in this section of the decision tree also lead towards developing co-designed/managed with Traditional Owners and if prior Traditional Owner Ecological Knowledge can be incorporated into the project.

An important design feature in the decision tree, was to allow for more than one site assisted recovery action to be included in the site stewardship plans (See Hastings Reef site stewardship plan). Answers in the site stewardship recommendations always lead back to the natural resilience indicators. This was to justify that the selected site has some capacity to alleviate heat stress through local scale hydrodynamics. More and more monitoring projects are now incorporating instruments that can monitor current flow, temperature and light. However, the decision tree does use some natural indicators such as the presence of large schools of small or large planktivores. Their presence may indicate sufficient flushing patterns to mediate heat stress. In terms of physical measurements, the decision tree question 55 asks *"Does the reef site experience flow patterns more than 0.3m/s?"* The threshold value was chosen based on evidence from Moore Reef, where sections of reef that bleached almost entirely in both 2016 and 2017 recovered with minimal mortality where current speeds periodically exceeded 0.3 m/s. Other sections of Moore Reef where bleaching was also high and current speeds were less 0.3 m/s experienced higher mortality.

How to develop site stewardship plans

The next section of the Kul-Bul Decision Tree Manual presents site stewardship plans for three coral reefs withing Yirrganydji Sea Country. We find it important that all site stewardship plans start with the recognition of the Traditional Owners and highlights their cultural management practices within that coral reef. The remainder of the plan summarises reef health, whether site assisted recovery actions are required and the level of inclusion for Traditional Owners in co-design/management of future projects.

We have provided working examples of the site stewardship plans each for each of the three reef sites at Hastings, Saxon and Norman Reefs. Following the site stewardship plan, we have included a copy for each decision tree to demonstrate how the questions were answered. Questions answered yes provide the relevant information to form the site stewardship plans. The working examples highlight the answers in yellow and where possible we have inserted data to support the answer. This help creates a visual understanding of the reef site. As the user progresses through the decision tree and if directed backwards to previous questions, the highlighted colour changes. The sequence of colours we used was yellow, turquoise, bright green, pink, red and teal.

Kul-Bul Decision Tree

Cultural Awareness

1. *Who are the Traditional Owners that have connection to _____ reef?*
    a. Name: _____..... 2
    b. If unknown contact North Queensland Land Council, Great Barrier Reef Marine Park Authority, Great Barrier Reef Foundation or Queensland Parks and Wildlife Service & Partnerships…..……... 2

2. *Have the Traditional Owners visited, access or used the reef/reef site in the past?*
    a. If yes……...4
    b. If no…..…….……...…..…7

3. *Do the Traditional Owners visit, access or use the reef/reef site today?*
    a. If yes…….11
    b. If no…..…….……...……..7

4. *Does the reef/reef site have animals of cultural significance to the Traditional Owners?*
    a. If yes……...5
    b. If no…..…….……...……..6

5. *Was the reef/reef site visited seasonally by the Traditional Owners and was use governed by Seasonal Indicators?*
    a. If yes……...6
    b. If no…..…….……...……..6

6. *Does the reef/reef site have ceremonial cultural significance to the Traditional Owners?*
    a. If yes……...3
    b. If no…..…….……...……..3

7. *Do the Traditional Owners not visit the reef/reef site due to limited access?*
    a. If yes…….21
    b. If no…..…….……...……..8

8. *Do the Traditional Owners not visit the reef/reef Site due to resources?*
    a. If yes…….21
    b. If no…..…….……...……..9

9. *Do the Traditional Owners not visit the reef/reef site due to historical reasons?*
    a. If yes…….21
    b. If no…..…….……...……10

10. *Do the Traditional Owners not visit the reef/reef site due to cultural reasons?*
    a. If yes…….11
    b. If no…..…….……...……11

11. *Are the Traditional Owners involved in **planning** management at the reef/reef site?*
    a. If yes…….12
    b. If no…..…….……...……18

12. *Do the Traditional Owners have any Indigenous Protected Areas (IPA's) within reef/reef site?*
    a. If yes…….13
    b. If no…..…….……...……13

13. *Does the Traditional Owners have Traditional Use Marine Resources Agreement (TUMRA) place at reef/reef site?*
    a. If yes……14
    b. If no…..…….……..…..14

14. *Does the Traditional Owners have a Land and Sea Ranger Program?*
    a. If yes…….15
    b. If no…..…….……..18

15. *Are the Traditional Owners involved in **monitoring** practices at the reef/reef site?*
    a. If yes…….16
    b. If no.…..…….……...……16

16. *Are the Traditional Owners involved in **compliance** practices at the reef/reef site?*
    a. If yes…….17
    b. If no…..…….……...……17

17. *Are the Traditional Owners involved in **pest management** practices at the reef/reef site?*
    a. If yes…….18
    b. If no…..…….……...……18

18. *Are the Traditional Owners involved in **events** at the reef/reef site?*
    a. If yes…….19
    b. If no…..…….……...……19

19. *Are the Traditional Owners involved in **education/interpretation** programs at the reef/reef site?*
    a. If yes…….20
    b. If no…..…….……...……20

20. *Are the Traditional Owners involved in **work experience** programs at the reef/reef site?*
    a. If yes…….22
    b. If no…..……..……...……22

Cultural Engagement

21. *Do you facilitate visits to Country for Traditional Owners?*
    a. If yes……..……22
    b. If no…..……..……...……11

22. *Are the Traditional Owners acknowledged during reef site visits?*
    a. If yes…….23
    b. If no…**Discuss protocols with Traditional Owners to deliver acknowledgment.**

23. *Have you contacted the Traditional Owners and asked for consent in conducting activities on their Country?*
    a. If yes ……24
    b. If no……**Outline your activities to the Traditional Owners and ask about protocols to gain consent**……24

24. *Are Traditional Owner knowledge and values incorporated into your own* ***education/interpretation*** *activities?*
    a. If yes…….28
    b. If no…..……..……...……25

25. *Are* ***Traditional Owner knowledge*** *and values incorporated into your own* ***sales/business*** *activities?*
    a. If yes…….28
    b. If no…..……..……...……26

26. *Are Traditional Owner knowledge and values incorporated into your own* ***monitoring*** *activities?*
    a. If yes…….28
    b. If no…..……..……...……27

27. *Is Traditional Owner knowledge and values incorporated into your own **site stewardship or reef management** activities?*
    a. If yes…….28
    b. If no…..…….……...……29

28. *Are there any protocols to safeguard Traditional Owner Knowledge?*
    a. If yes, **mark those that apply**..……..…….……..……25-27 then 29
        i. Memorandum of Understanding
        ii. Non-Disclosure Agreement
        iii. Legal Contract negotiating benefits for all parties.
    b. If no ……..…29

29. *What is the level of engagement with _____ (Traditional Owners) in potential site stewardship project?*
    a. Leading or co-leading ……**YES**…….….30
    b. Involved and engaged, mark all.
        i. Decision making……Yes / No
        ii. Planning ……Yes / No
        iii. In-water activity ……Yes / No
        iv. Training..……Yes / No
        v. Employment ……..Yes / No……30
    c. Contacted and given consent ……**YES**……...30

Biological Indicators

30. *Has Eye on the Reef Tourism Weekly Surveys been conducted at the reef site?*
    a. If yes…….31
    b. If no ……..……...…….37

31. *Has there been past evidence of **crown-of-thorns starfish (CoTS**) outbreaks at the reef site?*
    a. If yes…….57
    b. If no ……..……...…….32

32. *Has there been past evidence of **severe storm damag**e at the reef site?*
    a. If yes…….65
    b. If no ……..……...…….33

33. *Has there been past evidence of **mass coral bleaching** (> 40 colonies) at the reef site?*
    a. If yes…….43
    b. If no ……..……...…….34

34. *Has there been past evidence of **coral disease** outbreaks (<40 colonies) at the reef site?*
    a. If yes…….43
    b. If no ……..……...…….35

35. *Has there been past evidence of **Drupella snail** outbreaks (>40 colonies) at the reef site?*
    a. If yes…….61
    b. If no ……..……...…….36

36. *Has Reef Health Impact Surveys (RHIS) or Eye on the Reef Photo-point been conducted at the reef site?*
    a. If yes…….39
    b. If no ……..……...…….37

37. *Have other monitoring methodologies for example, Reef Check been conducted at the reef site?*
    a. If yes…….39
    b. If no ……..……...…….38

38. *Has the Kulbul complimentary site methodology (Appendix A) been conducted at reef site?*
    a. If yes…….39
    b. If no ……..…. **see methodology (Appendix A)**

39. *Is **Live Coral** the dominant benthos category at the reef site?*
    a. If yes……..…45
    b. If no …….40

40. *Is **Live Coral Rock** the dominant benthos category at the reef site?*
    a. If yes……45
    b. If no …….41

41. *Is **Rubble** the dominant benthos category at the reef site?*
    a. If yes…….65
    b. If no ……...……..…….42

42. *Is **Macroalgae** the dominant benthos category at the reef site?*
    a. If yes…….70
    b. If no …….43

43. *Is **Recently Dead Coral** the dominant benthos category at the reef site?*

a. If yes…….45

b. If no …….44

44. *Is **Sand** the dominant benthos category at the reef site?*

a. If yes…….72

b. If no …….45

45. *Is the percentage of live coral at the reef site greater than 30%?*

a. If yes…….46

b. If no……..65

46. *Does the dominant coral group at the site have an axial polyp?*

a. If yes…….47

b. If no …….48

c. If unknown……...**see methodology (Appendix A)**

47. *What is the dominant coral group at the reef site? ……*.....49

a. Plate

b. Branching

c. Bushy

d. Bottlebrush

48. *What is the dominant coral group at the reef site?*

    a. Boulder
    b. Foliose
    c. Branching (no axial polyp)
    d. Bushy (no axial polyp)
    e. Mushroom
    f. Soft coral
    g. **Consider site assisted recovery actions technique to increase coral diversity and resilience**…….65 or 70

Natural Resilience Indicators

49. *Have these corals broadcast spawned in recent years at the reef site?*
    a. If yes……..…50
    b. If no……...……...51

50. *Was the rate of coral spawning greater than 250 eggs/minute for most species?*
    a. If yes…..……**A potential good site for coral spawn catching to rear and seed larvae for other locations** ……..….51
    b. If no……..…..……..51
    c. If unknown……..**see methodology (Appendix B)**

51. *Was there coral recruitment noticed on settlement tiles at the reef site?*
    a. If yes…….52
    b. If no……...……..54 or 55
    c. If unknown…….. **see methodology (Appendix C)**

52. *Was the mean number of coral recruits greater then 40 recruits/tile at the reef site?*
    a. If yes…….53
    b. If no …….70

53. *Are the broadcast spawning recruits greater than 50% of the recruitment assemblage (tiles) at the reef site?*
    a. If yes……. **The site does not require site assisted recovery actions**...……71
    b. If no.…….70

54. *Are coral predators present at the reef site?*
    a. If yes for crown-of-thorns starfish (CoTS)……...57
    b. If yes for Drupella snails……..61
    c. If no……...…55

55. *Does the reef site experience flow patterns more than 0.3m/s?*

a. If yes…… **The site has the capacity to recover from heat stress continue with appropriate site assisted recovery techniques.**

b. If no.…….56

c. If unknown……..…… **see methodology (Appendix D)**

56. *Are there large schools of planktivores regularly (tidal) observed at the reef site?*

a. If yes…… **The site potentially has the capacity to recover from heat stress continue with appropriate site assisted recovery techniques.**

b. If no…… **Emphasise caution if proceeding with site assisted recovery techniques and research potential cooling and shading techniques to mediate heat stress.**

Site Stewardship Recommendations

57. *Is the density of crown-of-thorn starfish (CoTS) > 2 individuals per hectare?*
    a. If yes…….58
    b. If no ……...….32 or 55
    c. If unknown……...38

58. *Is there regular crown-of-thorn starfish (CoTS) control programs at the reef site?*
    a. If yes…….60
    b. If no……..**Consider implementing a control program**……...59

59. *Is there Traditional Owner Ecological Knowledge of crown-of-thorns starfish (CoTS) that can be incorporated into control and interpretation programs?*
    a. If yes……..**Discuss protocols to safeguard Traditional Owner Ecological Knowledge (Appendix E)** ……....……..…45
    b. If no.…….45

60. *Are Traditional Owners involved in crown-of-thorn starfish (CoTS) control programs at the reef site?*
    a. If yes…….59
    b. If no……..**Consider capacity training programs or initiatives…**…..45

61. *Is the density of Drupella snails greater than 200 individuals per hectare?*
    a. If yes…….62
    b. If no.……...….36 or 55
    c. If unknown……...38

62. *Is there regular Drupella snails control programs at the reef site?*
    a. If yes…….63
    b. If no.……**Consider implementing a control program**…….45

63. *Is there Traditional Owner Ecological Knowledge of Drupella snails that can be incorporated into control and interpretation programs?*
    a. If yes……...**Discuss protocols to safeguard Traditional Owner Ecological Knowledge (Appendix E)**……45
    b. If no.……45

64. *Are Traditional Owners involved in Drupella snail control programs at the reef site?*
    a. If yes……62
    b. If no…….. **Consider capacity training programs or initiatives**…….45

65. *Is the percentage of rubble at the reef site greater than 10%?*
    a. If yes……66
    b. If no……..42
    c. If unknown……...36

66. *Is the rubble patch at the reef site greater than 50m^2?*
    a. If yes……**Consider coral rubble stabilisation project with Mars Assisted Reef Restoration system or an alternative proven method**……67
    b. If no…….….42

67. *Are grazing herbivores present at the reef site?*
    a. If yes……**Rubble stabilisation projects require less maintenance**…….68
    b. If no.……..……...…….....68

68. *Is there Traditional Owner Ecological Knowledge of severe storm damage and recovery patterns that can be incorporated into site assisted recovery actions?*
    a. If yes……..… **Discuss protocols to safeguard Traditional Owner Ecological Knowledge (Appendix E)**……....69
    b. If no……..69

69. *Are there coral fragments of opportunity greater than 0.5 per m^2 at the reef site?*
    a. If yes……**Continue with site assisted recovery techniques**…….70
    b. If no……..**Consider collection of coral fragments from other reefs, check the Reef Authority translocation guidelines** or ……72

70. *Is the live coral rock substrate greater than 20% at the reef site and covered in thick turfing algae mats or other macroalgae?*
    a. If yes……**Consider macroalgae removal techniques prior to larval seeding or coral out planting techniques using coral clips**…….....…71
    b. If yes (with no macroalgae)……. **Consider coral larval seeding techniques or coral out-planting with coral clip**…….71
    c. If no……..36

71. *Is there Traditional Owner Ecological Knowledge of coral spawning and connectivity that can be incorporated into site assisted recovery actions?*
    a. If yes…….**..Discuss protocols to safeguard Traditional Owner Ecological Knowledge (Appendix E)**…….....54
    b. If no…….54

72. *Are there sufficient sandy patches to place in a moored coral nursery at the reef site?*
    a. If yes……..**Consider Coral Nurture nurseries or Reef Restoration Trees** ……....……...….45 or 54
    b. If no…… **Consider collection of coral fragments from other reefs, check The Reef Authority translocation guidelines**…...……..……45 or 54

Hastings Reef – site stewardship plan

The Yirrganydji people are the traditional custodians of Hastings Reef and have related to Hastings in the past (pre-European) and present. This Sea Country has animals of cultural significance, and the reef was visited seasonally via seasonal indicators. The Yirrganydji have been actively involved in the planning management of Hastings Reef with a Traditional Use of Marine Resource Agreement (TUMRA) with The Great Barrier Reef Marine Park Authority. The Yirrganydji people through Dawul Wuru Aboriginal Corporation manage a Land and Sea Country Ranger program that visits Hastings Reef. At this reef they have been involved in monitoring, compliance, pest management, education and work experience programs.

The tourism operator Reef Magic/Dreamtime acknowledge and recognises the Yirrganydji people as the Traditional Custodians of Hastings Reef. This has allowed a partnership to develop where we regularly contact Yirrganydji for consent to carry out activities on their Sea Country. Yirrganydji Traditional Owner knowledge and values have been incorporated into our education and interpretation programs which was safeguarded through a Memorandum of Understanding between the parties.

Overall, live coral with a mean coverage of 37% was the dominant benthos at the Reef Magic/Dreamtime reef site at Hastings Reef named “Kul-bul”. However, the dominant coral group was slow growing boulder corals and general diversity of coral was low, especially in the branching coral family Acroporidae. We suggest, to increase overall diversity and resilience of the site, to consider reef assisted recovery actions.

The Kul-Bul tourism site at Hastings Reef had evidence of severe storm damage and there were two large coral rubble areas greater than 100 m^2 each. The rubble areas are suited for coral rubble stabilisation using the Mars Assisted Reef Restoration System (MARRS). The Reef Stars require coral fragments of opportunity; however, fragments were low in abundance at this reef, and we suggest collecting fragments from a neighbouring coral reef. Saxon Reef just 20 minutes away had a high abundance of coral fragments of opportunity with many species from the family Acroporidae. The Hastings site “Kul-Bul” had high abundance of grazing herbivores that ensures less maintenance would be required in the first

few months of Reef Star deployment. Herbivorous fish help to reduce competition between algae and freshly secured coral fragments to the Reef Stars.

In addition, the site also has large areas of live coral rock that are suitable for larval seeding or coral out-planting. Given that overall coral diversity was low we recommend larval seeding over nurseries and out-planting. However, coral spawn would be best collected from neighbouring reefs with higher coral abundance and diversity, then transported to Hastings Reef and seeded on site. In support of site assisted recovery actions, the risk of coral predators was low, and tidal current flow patterns in this area were considered adequate to mediate coral heat stress during a marine heat wave.

Through the Kul-bul Decision Tree, GBR Biology, Reef Restoration Foundation and the Dawul Wuru Aboriginal Corporation have identified two potential site assisted recovery actions in MARRS Reef Stars and coral larval seeding for Hastings Reef. Eye on the Reef and Kul-bul monitoring methods were used to determine current reef health. Further it is possible to incorporate Traditional Owner Ecological Knowledge into future projects and such projects to be co-designed and managed with the Yirrganydji people.

Working Decision Tree Example (Hastings Reef)

Cultural Awareness

1. *Who are the Traditional Owners that have connection to **Hastings Reef**.*
    a. Name: **The Yirrganydji People**……..... 2
    b. If unknown contact North Queensland Land Council, Great Barrier Reef Marine Park Authority, Great Barrier Reef Foundation or Queensland Parks and Wildlife Service & Partnerships…..……... 2

2. *Have the Traditional Owners visited, access or used the reef/reef site in the past?*
    a. If yes……...4
    b. If no…..…….……...…..…7

3. *Do the Traditional Owners visit, access or use the reef/reef site today?*
    a. If yes…….11
    b. If no…..…….……...……..7

4. *Does the reef/reef site have animals of cultural significance to the Traditional Owners?*
    a. If yes……...5
    b. If no…..…….……...……..6

5. *Was the reef/reef site visited seasonally by the Traditional Owners and was use governed by Seasonal Indicators?*
    a. If yes……...6
    b. If no…..…….……...……..6

6. *Does the reef/reef site have ceremonial cultural significance to the Traditional Owners?*
    a. If yes……...3
    b. If no…..……..……...……..3

7. *Do the Traditional Owners not visit the reef/reef site due to limited access?*
    a. If yes…….21
    b. If no…..……..……...……..8

8. *Do the Traditional Owners not visit the reef/reef Site due to resources?*
    a. If yes…….21
    b. If no…..……..……...……..9

9. *Do the Traditional Owners not visit the reef/reef site due to historical reasons?*
    a. If yes…….21
    b. If no…..……..……...……10

10. *Do the Traditional Owners not visit the reef/reef site due to cultural reasons?*
    a. If yes…….11
    b. If no…..……..……...……11

11. *Are the Traditional Owners involved in **planning** management at the reef/reef site?*
    a. If yes…….12
    b. If no…..……..……...……18

12. *Do the Traditional Owners have any Indigenous Protected Areas (IPA's) within reef/reef site?*
    a. If yes…….13
    b. If no…..……..……...……13

13. *Does the Traditional Owners have Traditional Use Marine Resources Agreement (TUMRA) place at reef/reef site?*
    a. If yes……14
    b. If no…..……..……..…..14

14. *Does the Traditional Owners have a Land and Sea Ranger Program?*
    a. If yes……15
    b. If no…..……..……..18

15. *Are the Traditional Owners involved in **monitoring** practices at the reef/reef site?*
    a. If yes……16
    b. If no…..……..……...……16

16. *Are the Traditional Owners involved in **compliance** practices at the reef/reef site?*
    a. If yes……17
    b. If no…..……..……...……17

17. *Are the Traditional Owners involved in **pest management** practices at the reef/reef site?*
    a. If yes……18
    b. If no…..……..……...……18

18. *Are the Traditional Owners involved in **events** at the reef/reef site?*
    a. If yes……19
    b. If no…..……..……...……19

19. *Are the Traditional Owners involved in **education/interpretation** programs at the reef/reef site?*
    a. If yes……20
    b. If no…..……..……...……20

20. *Are the Traditional Owners involved in **work experience** programs at the reef/reef site?*
    a. If yes……22
    b. If no…..……..……...……22

Cultural Engagement

21. *Do you facilitate visits to Country for Traditional Owners?*
    a. If yes……..……22
    b. If no…..……..……...……11

22. *Are the Traditional Owners acknowledged during reef site visits?*
    a. If yes…….23
    b. If no…**Discuss protocols with Traditional Owners to deliver acknowledgment.**

23. *Have you contacted the Traditional Owners and asked for consent in conducting activities on their Country?*
    a. If yes ……24
    b. If no……**Outline your activities to the Traditional Owners and ask about protocols to gain consent**……24

24. *Are Traditional Owner knowledge and values incorporated into your own* ***education/interpretation*** *activities?*
    a. If yes…….28
    b. If no…..……..……...……25

25. *Are* ***Traditional Owner knowledge*** *and values incorporated into your own* ***sales/business*** *activities?*
    a. If yes…….28
    b. If no…..……..……...……26

26. *Are Traditional Owner knowledge and values incorporated into your own* ***monitoring*** *activities?*
    a. If yes…….28
    b. If no…..……..……...……27

27. *Is Traditional Owner knowledge and values incorporated into your own **site stewardship or reef management** activities?*
    a. If yes……28
    b. If no…..……..……..……29

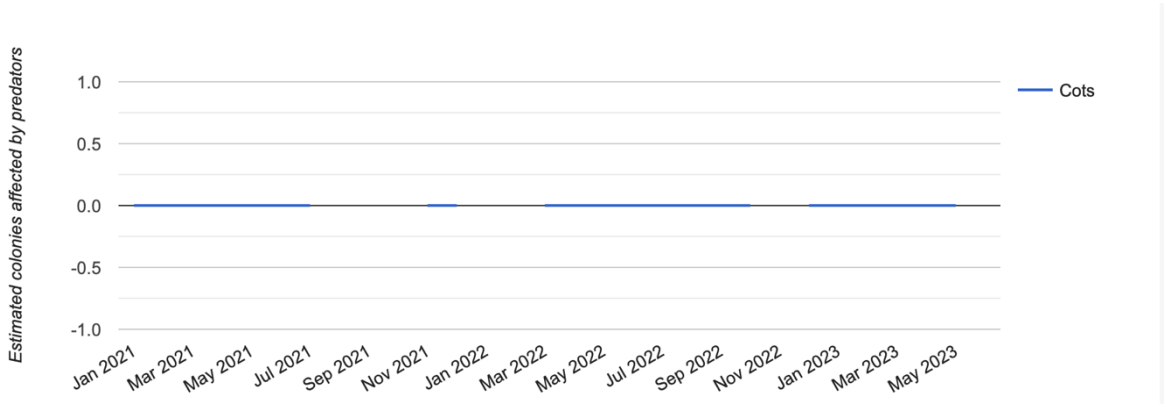
28. *Are there any protocols to safeguard Traditional Owner Knowledge?*
    a. If yes, **mark those that apply**..……..……..……..……25-27 then 29
        i. Memorandum of Understanding
        ii. Non-Disclosure Agreement
        iii. Legal Contract negotiating benefits for all parties
    b. If no ……..…29

29. *What is the level of engagement with Yirrganydji (Traditional Owners) in potential site stewardship project?*
    a. Leading or co-leading ……**YES**…….30
    b. Involved and engaged, mark all
        i. Decision making……Yes / No
        ii. Planning ……Yes / No
        iii. In-water activity ……Yes / No
        iv. Training..……Yes / No
        v. Employment ……..Yes / No……30
    c. Contacted and given consent ……**YES**……...30

Biological Indicators

30. *Has Eye on the Reef Tourism Weekly Surveys been conducted at the reef site?*
    a. If yes……31
    b. If no ……..……...…….37

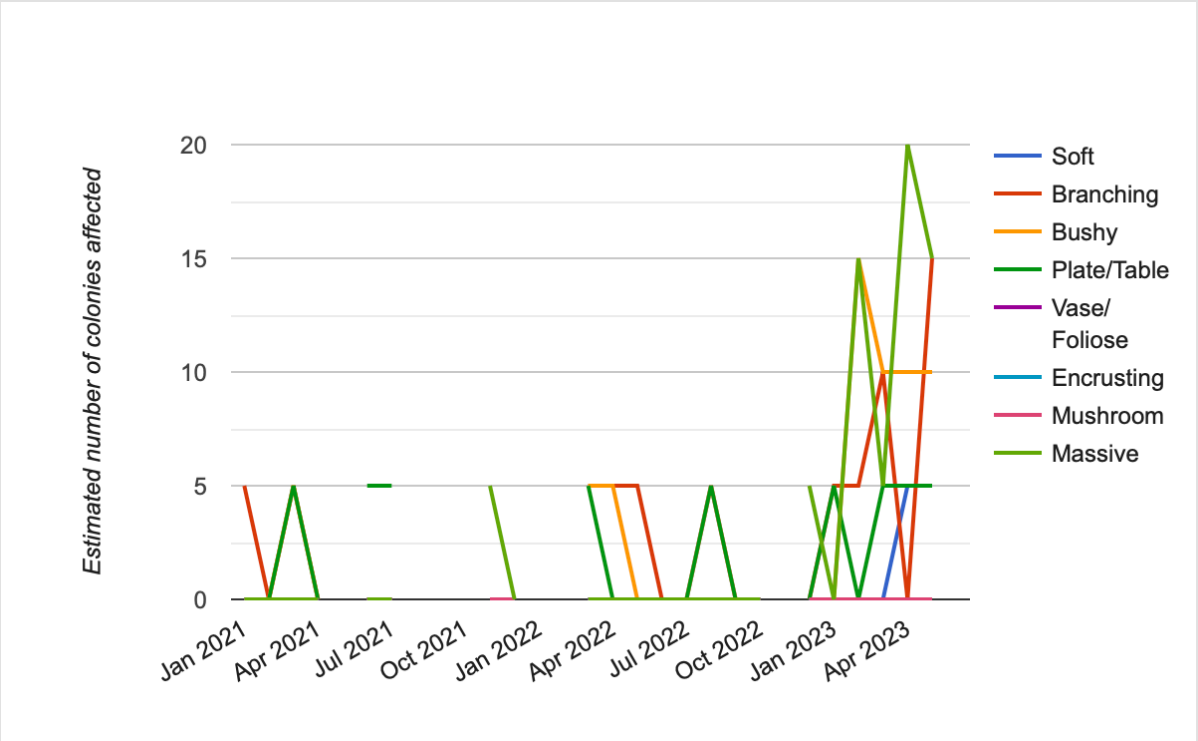
31. *Has there been past evidence of* ***crown-of-thorns starfish (CoTS)*** *outbreaks at the reef site?*
    a. If yes…….57
    b. If no ……..……...…….32



32. *Has there been past evidence of **severe storm damage** (>40 colonies) at the reef site?*

a. If yes……65

b. If no ……..……...…….33



33. *Has there been past evidence of **mass coral bleaching** (>40 colonies) at the reef site?*

a. If yes……43

b. If no ……..……...…….34

34. *Has there been past evidence of **coral disease** outbreaks (>40 colonies) at the reef site?*

a. If yes……43

b. If no ……..……...…….35

35. *Has there been past evidence of **Drupella snail** outbreaks (> 40 colonies) at the reef site?*

a. If yes……61

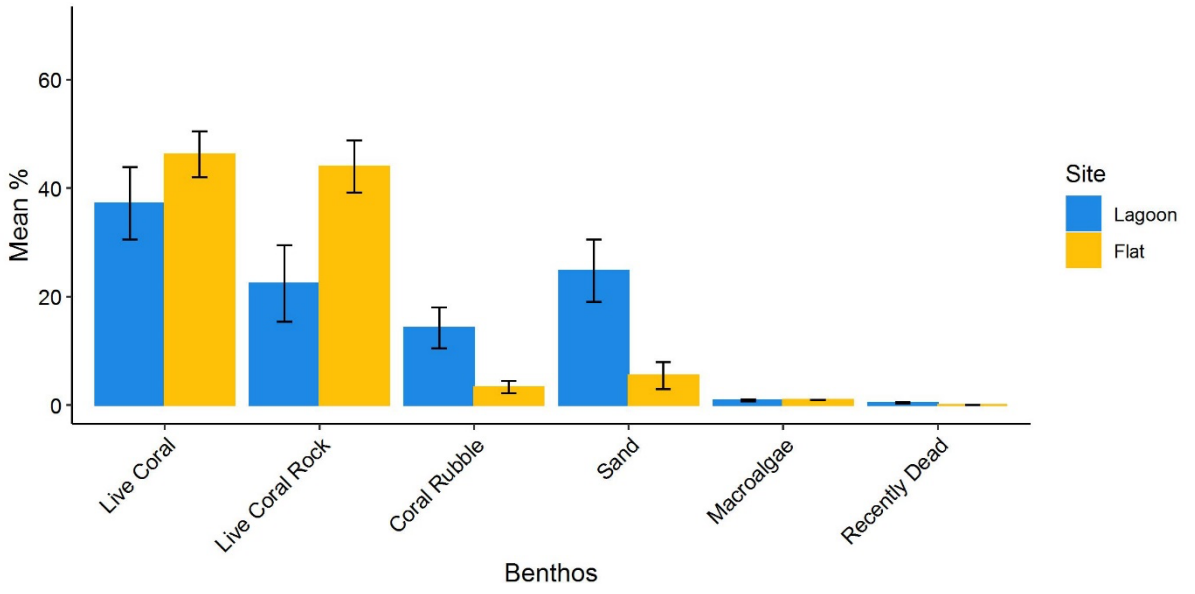
b. If no ……..……...…….36

36. *Has Reef Health Impact Surveys (RHIS) or Eye on the Reef Photo-point been conducted at the reef site?*
    a. If yes……39
    b. If no ……..……...…….37

37. *Have other monitoring methodologies for example, Reef Check been conducted at the reef site?*
    a. If yes…….39
    b. If no ……..……...…….38

38. *Has the Kulbul complimentary site methodology (Appendix A) been conducted at reef site?*
    a. If yes…….39
    b. If no ……..…. **see methodology (Appendix A)**

39. *Is **Live Coral** the dominant benthos category at the reef site?*
    a. If yes……45 or 55
    b. If no …….40



40. *Is **Live Coral Rock** the dominant benthos category at the reef site?*
    a. If yes……45
    b. If no ……41

41. *Is **Rubble** the dominant benthos category at the reef site?*
    a. If yes……65
    b. If no ……...……..…….42

42. *Is **Macroalgae** the dominant benthos category at the reef site?*
    a. If yes……70
    b. If no ……43

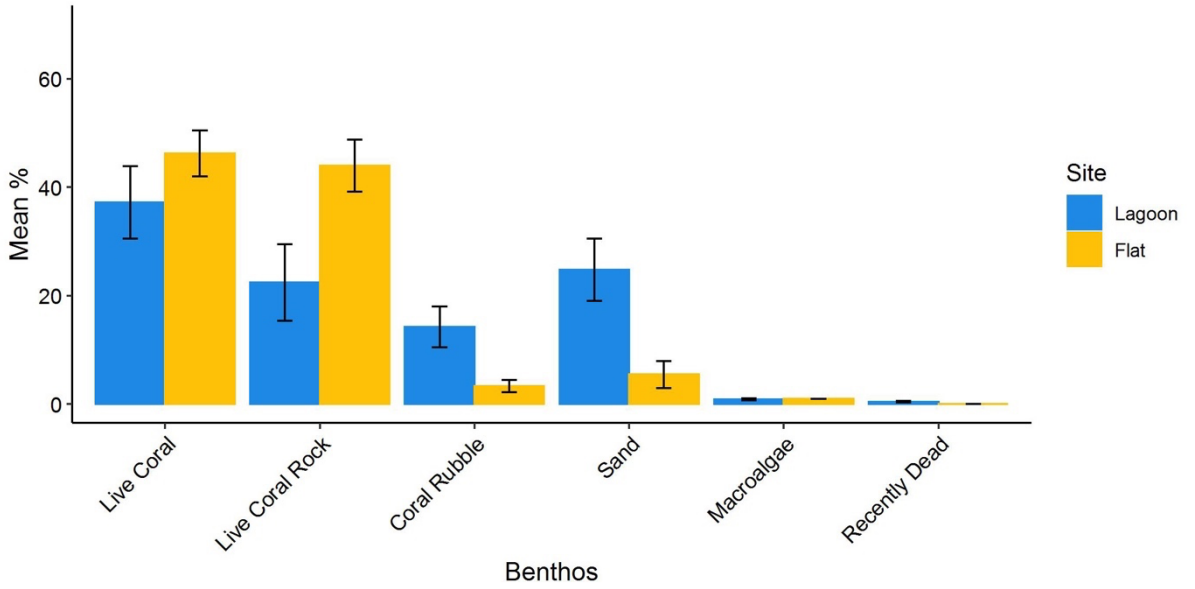
43. *Is **Recently Dead Coral** the dominant benthos category at the reef site?*
    a. If yes……45
    b. If no ……44

44. *Is **Sand** the dominant benthos category at the reef site?*
    a. If yes……72
    b. If no ……45

45. *Is the percentage of live coral at the reef site greater than 30%?*

a. If yes……46

b. If no……..65

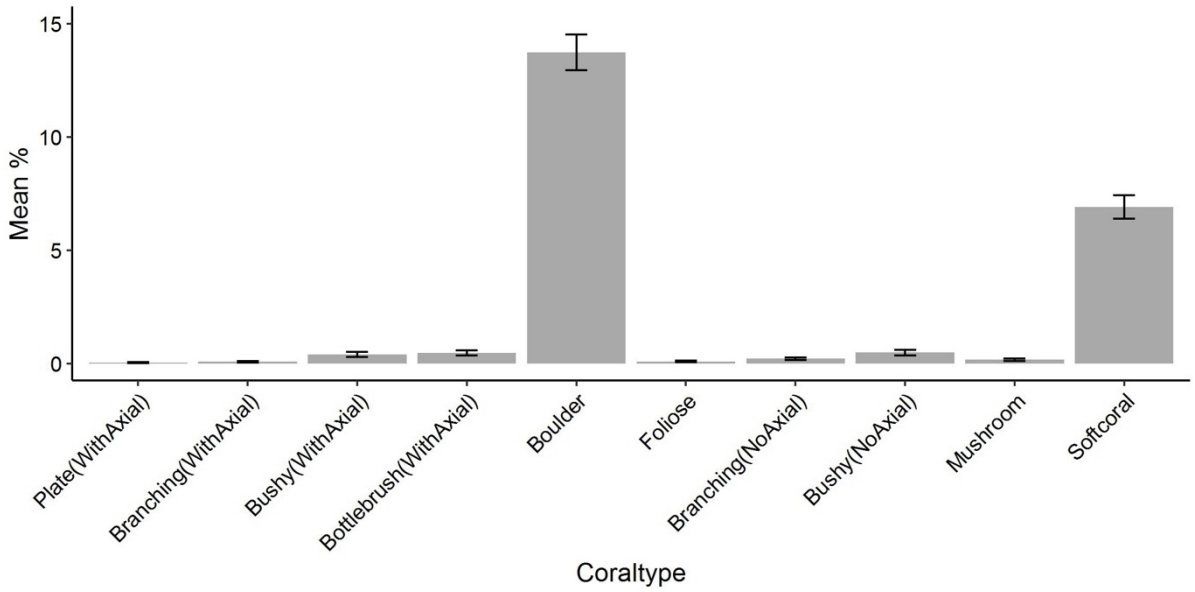


46. *Does the dominant coral group at the site have an axial polyp?*

a. If yes……47

b. If no ……48

c. If unknown……...**see methodology (Appendix A)**



47. *What is the dominant coral group at the reef site?* ……..49

a. Plate
b. Branching
c. Bushy
d. Bottlebrush

48. *What is the dominant coral group at the reef site?*

a. Boulder
b. Foliose
c. Branching (no axial polyp)
d. Bushy (no axial polyp)
e. Mushroom
f. Soft coral
g. **Consider site assisted recovery actions technique to increase coral diversity and resilience**……....65 or 70

Natural Resilience Indicators

49. *Have these corals broadcast spawned in recent years at the reef site?*
    a. If yes……..…50
    b. If no……..51

50. *Was the rate of coral spawning greater than 250 eggs/minute for most species?*
    a. If yes…..……**A potential good site for coral spawn catching to rear and seed larvae for other locations** ……..….51
    b. If no……..…..……..51
    c. If unknown……..**see methodology (Appendix B)**

51. *Was there coral recruitment noticed on settlement tiles at the reef site?*
    a. If yes…….52
    b. If no……...……..54 or 55
    c. If unknown…….. **see methodology (Appendix C)**

52. *Was the mean number of coral recruits greater then 40 recruits/tile at the reef site?*
    a. If yes…….53
    b. If no …….70

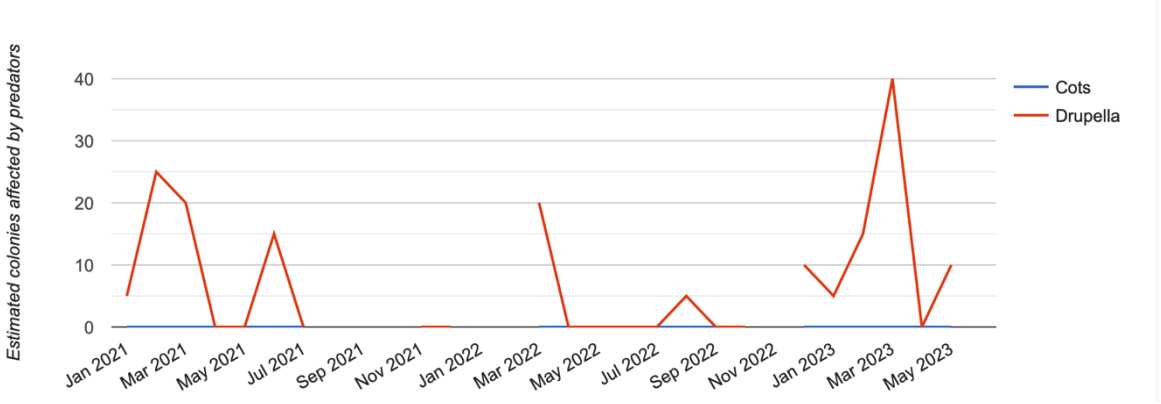
53. *Are the broadcast spawning recruits greater than 50% of the recruitment assemblage (tiles) at the reef site?*
    a. If yes……. **The site does not require site assisted recover**……..……71
    b. If no.…….70

54. *Are coral predators present at the reef site?*

a. If yes for crown-of-thorns starfish (CoTS)……...57

b. If yes for Drupella snails……..61

c. If no……..…55

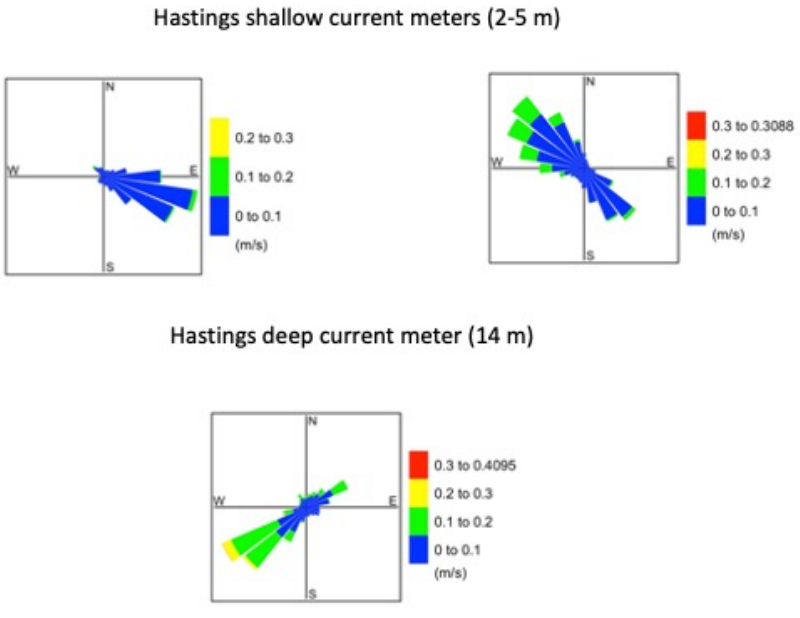


55. *Does the reef site experience flow patterns more than 0.3m/s?*

a. If yes…… **The site has the capacity to recover from heat stress continue with appropriate site assisted recovery techniques.**

b. If no……56

c. If unknown……..…… **see methodology (Appendix D)**



Current flow was higher deep compared to shallow, however shallow and deep can experience strong bimodal currents indicating tidal flushing of the lagoon.

56. *Are there large schools of planktivores regularly (tidal) observed at the reef site?*
    a. If yes…… **The site potentially has the capacity to recover from heat stress continue with appropriate site assisted recovery techniques.**
    b. If no…… **Emphasise caution if proceeding with site assisted recovery techniques and research potential cooling and shading techniques to mediate heat stress.**

Site Stewardship Recommendations

57. *Is the density of crown-of-thorn starfish (CoTS) > 2 individuals per hectare?*
    a. If yes…….58
    b. If no ……...….32 or 55
    c. If unknown……...38

58. *Is there regular crown-of-thorn starfish (CoTS) control programs at the reef site?*
    a. If yes…….60
    b. If no……..**Consider implementing a control program**……...59

59. *Is there Traditional Owner Ecological Knowledge of crown-of-thorns starfish (CoTS) that can be incorporated into control and interpretation programs?*
    a. If yes……..**Discuss protocols to safeguard Traditional Owner Ecological Knowledge (Appendix E)**……45
    b. If no…….45

60. *Are Traditional Owners involved in crown-of-thorn starfish (CoTS) control programs at the reef site?*
    a. If yes…….59
    b. If no……..**Consider capacity training programs or initiatives…**…..45

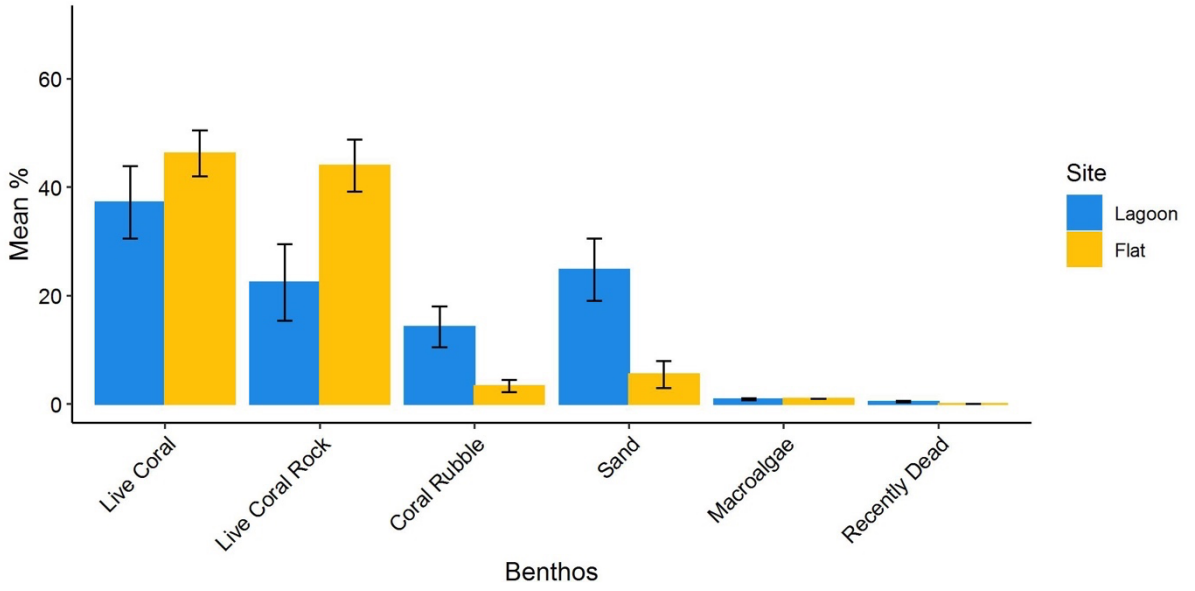
61. *Is the density of Drupella snails greater than 200 individuals per hectare?*
    a. If yes…….62
    b. If no……...….36 or 55
    c. If unknown……...38

62. *Is there regular Drupella snails control programs at the reef site?*
    a. If yes…….63
    b. If no……**Consider implementing a control program**…….45

63. *Is there Traditional Owner Ecological Knowledge of Drupella snails that can be incorporated into control and interpretation programs?*
    a. If yes……...**Discuss protocols to safeguard Traditional Owner Ecological Knowledge (Appendix E)**……45
    b. If no……45

64. *Are Traditional Owners involved in Drupella snail control programs at the reef site?*
    a. If yes……62
    b. If no…….. **Consider capacity training programs or initiatives**…….45

65. *Is the percentage of rubble at the reef site greater than 10%?*
    a. If yes……66
    b. If no……..42
    c. If unknown……...36



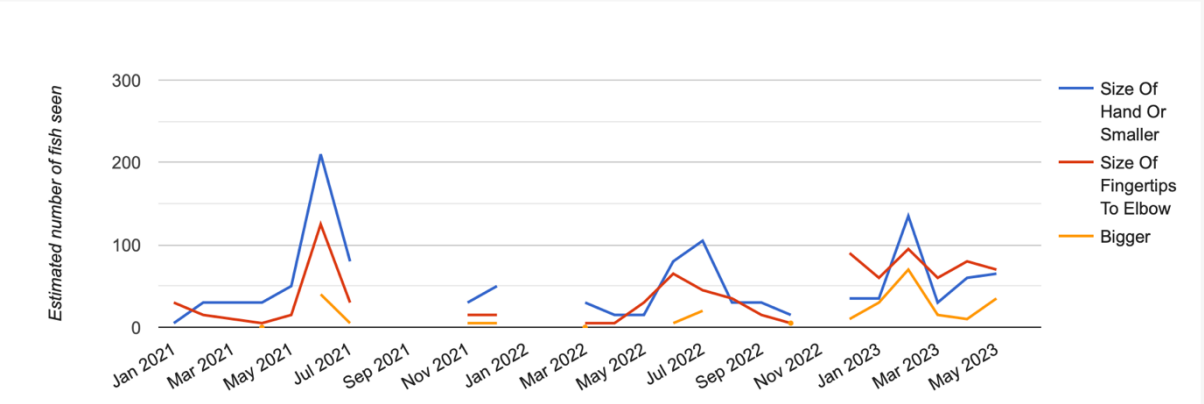
66. *Is the rubble patch at the reef site greater than 50m^2?*
    a. If yes……**Consider coral rubble stabilisation project with Mars Assisted Reef Restoration system or an alternative proven method**……67
    b. If no……42

There are two patches of Rubble that are ~100m^2 each.

67. *Are grazing herbivores present at the reef site?*

a. If yes……**Rubble stabilisation projects require less maintenance**…….68

b. If no……..……...…….....68



68. *Is there Traditional Owner Ecological Knowledge of severe storm damage and recovery patterns that can be incorporated into site assisted recovery actions?*

a. If yes…… **Discuss protocols to safeguard Traditional Owner Ecological Knowledge (Appendix E)**……....69

b. If no……..69

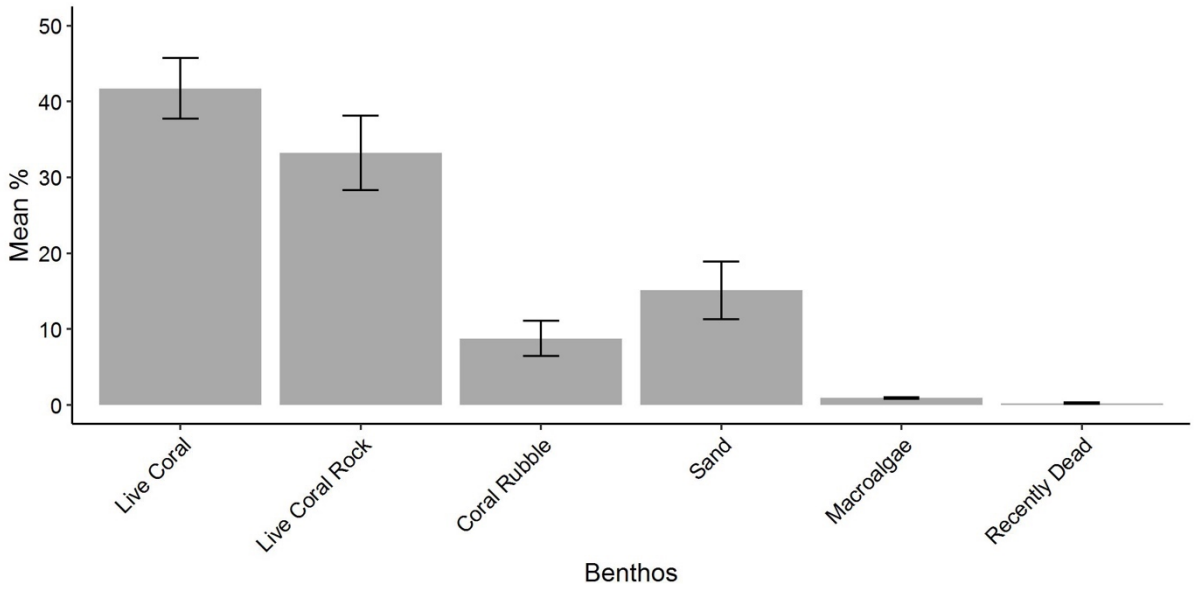
69. *Are there coral fragments of opportunity greater than 0.5 per m^2 at the reef site?*

a. If yes……**Continue with site assisted recovery techniques**…….70

b. If no……..**Consider collection of coral fragments from other reefs, check the Reef Authority translocation guidelines** or ……72

Fragment density was 0.19 Frags/m^2 (Kul-bul methodology)

70. *Is the live coral rock greater than 20% at the reef site and covered in thick turfing algae mats or other macroalgae?*
    a. If yes……**Consider macroalgae removal techniques prior to larval seeding or coral out planting techniques using coral clips**……...……71
    b. If yes (with no macroalgae) …… **Consider coral larval seeding techniques or coral out-planting with coral clip**……71
    c. If no……..36



71. *Is there Traditional Owner Ecological Knowledge of coral spawning and connectivity that can be incorporated into site assisted recovery actions?*
    a. If yes…….**Discuss protocols to safeguard Traditional Owner Ecological Knowledge (Appendix E)**…….....54
    b. If no…….54

72. *Are there sufficient sandy patches to place in a moored coral nursery at the reef site?*
    a. If yes……..**Consider Coral Nurture nurseries or Reef Restoration Trees** ……....……...….45 or 54
    b. If no…… **Consider collection of coral fragments from other reefs, check The Reef Authority translocation guidelines**…..……..……45 or 54

Saxon Reef – site stewardship plan

The Yirrganydji people are the traditional custodians of Saxon Reef and have related to Saxon in the past (pre-European) and present. This Sea Country has animals of cultural significance, and the reef was visited seasonally via seasonal indicators. The Yirrganydji have been actively involved in the planning management of Saxon Reef with a Traditional Use of Marine Resource Agreement (TUMRA) with The Great Barrier Reef Marine Park Authority. The Yirrganydji people through Dawul Wuru Aboriginal Corporation manage a Land and Sea Country Ranger program that visits Saxon Reef. At this reef they have been involved in monitoring, compliance, pest management, education and work experience programs.

The tourism operator Reef Magic/Dreamtime acknowledge and recognises the Yirrganydji people as the Traditional Custodians of Saxon Reef. This has allowed a partnership to develop where we regularly contact Yirrganydji for consent to carry out activities on their Sea Country. Yirrganydji Traditional Owner knowledge and values have been incorporated into our education and interpretation programs which was safeguarded through a Memorandum of Understanding between the parties.

Overall, live coral with a mean coverage of 60% was the dominant benthos at the Reef Magic/Dreamtime reef site at Saxon Reef named “Magic Wall”. The dominant coral group was boulder corals, however there was high diversity and abundance in all coral groups including the fast-growing reef building branching corals, the Acroporidae. The corals have broadcast spawned in the past with high rates of egg release. We suggest that this could be a potential location to collect coral spawn, rear larvae and seed at other locations. However, local recruitment in the area was considered poor and given the high percentage of live coral rock on the reef flat, the habitat represents an excellent location to seed coral larvae. Moreover, the site had low risk from coral predators and there were sufficient tidal flow patterns to regularly flush the reef flat and lagoon to combat coral heat stress during marine heatwaves.

Through the Kul-bul Decision Tree, GBR Biology, Reef Restoration Foundation and the Dawul Wuru Aboriginal Corporation identified that Saxon Reef site “Magic Wall” was in good condition and represents a great location for coral larval collection and potential

seeding. Eye on the Reef and Kul-bul monitoring methods were used to determine current reef health. Further it is possible to incorporate Traditional Owner Ecological Knowledge into future projects and such projects to be co-designed and managed with the Yirrganydji people.

Working Decision Tree Example (Saxon Reef)

Cultural Awareness

1. *Who are the Traditional Owners that have connection to **Saxon Reef**.*
    a. Name: **The Yirrganydji People**……..... 2
    b. If unknown contact North Queensland Land Council, Great Barrier Reef Marine Park Authority, Great Barrier Reef Foundation or Queensland Parks and Wildlife Service & Partnerships…..……... 2

2. *Have the Traditional Owners visited, access or used the reef/reef site in the past?*
    a. If yes……...4
    b. If no…..…….……...…..…7

3. *Do the Traditional Owners visit, access or use the reef/reef site today?*
    a. If yes…….11
    b. If no…..…….……...……..7

4. *Does the reef/reef site have animals of cultural significance to the Traditional Owners?*
    a. If yes……...5
    b. If no…..…….……...……..6

5. *Was the reef/reef site visited seasonally by the Traditional Owners and was use governed by Seasonal Indicators?*
    a. If yes……...6
    b. If no…..…….……...……..6

6. *Does the reef/reef site have ceremonial cultural significance to the Traditional Owners?*
    a. If yes……...3
    b. If no…..……..……...……..3

7. *Do the Traditional Owners not visit the reef/reef site due to limited access?*
    a. If yes…….21
    b. If no…..……..……...……..8

8. *Do the Traditional Owners not visit the reef/reef Site due to resources?*
    a. If yes…….21
    b. If no…..……..……...……..9

9. *Do the Traditional Owners not visit the reef/reef site due to historical reasons?*
    a. If yes…….21
    b. If no…..……..……...……10

10. *Do the Traditional Owners not visit the reef/reef site due to cultural reasons?*
    a. If yes…….11
    b. If no…..……..……...……11

11. *Are the Traditional Owners involved in **planning** management at the reef/reef site?*
    a. If yes…….12
    b. If no…..……..……...……18

12. *Do the Traditional Owners have any Indigenous Protected Areas (IPA's) within reef/reef site?*
    a. If yes…….13
    b. If no…..……..……...……13

13. *Does the Traditional Owners have Traditional Use Marine Resources Agreement (TUMRA) place at reef/reef site?*
    a. If yes……14
    b. If no…..……..……..…..14

14. *Does the Traditional Owners have a Land and Sea Ranger Program?*
    a. If yes……15
    b. If no…..……..……..18

15. *Are the Traditional Owners involved in **monitoring** practices at the reef/reef site?*
    a. If yes……16
    b. If no…..……..……...……16

16. *Are the Traditional Owners involved in **compliance** practices at the reef/reef site?*
    a. If yes……17
    b. If no…..……..……...……17

17. *Are the Traditional Owners involved in **pest management** practices at the reef/reef site?*
    a. If yes……18
    b. If no…..……..……...……18

18. *Are the Traditional Owners involved in **events** at the reef/reef site?*
    a. If yes……19
    b. If no…..……..……...……19

19. *Are the Traditional Owners involved in **education/interpretation** programs at the reef/reef site?*
    a. If yes……20
    b. If no…..……..……...……20

20. *Are the Traditional Owners involved in **work experience** programs at the reef/reef site?*
    a. If yes……22
    b. If no…..……..……...……22

Cultural Engagement

21. *Do you facilitate visits to Country for Traditional Owners?*
    a. If yes……..……22
    b. If no…..……...……11

22. *Are the Traditional Owners acknowledged during reef site visits?*
    a. If yes…….23
    b. If no…**Discuss protocols with Traditional Owners to deliver acknowledgment.**

23. *Have you contacted the Traditional Owners and asked for consent in conducting activities on their Country?*
    a. If yes ……24
    b. If no……**Outline your activities to the Traditional Owners and ask about protocols to gain consent**……24

24. *Are Traditional Owner knowledge and values incorporated into your own* ***education/interpretation*** *activities?*
    a. If yes…….28
    b. If no…..……...……25

25. *Are* ***Traditional Owner knowledge*** *and values incorporated into your own* ***sales/business*** *activities?*
    a. If yes…….28
    b. If no…..……...……26

26. *Are Traditional Owner knowledge and values incorporated into your own* ***monitoring*** *activities?*
    a. If yes…….28
    b. If no…..……...……27

27. *Is Traditional Owner knowledge and values incorporated into your own **site stewardship or reef management** activities?*
    a. If yes……28
    b. If no…..……..……..……29

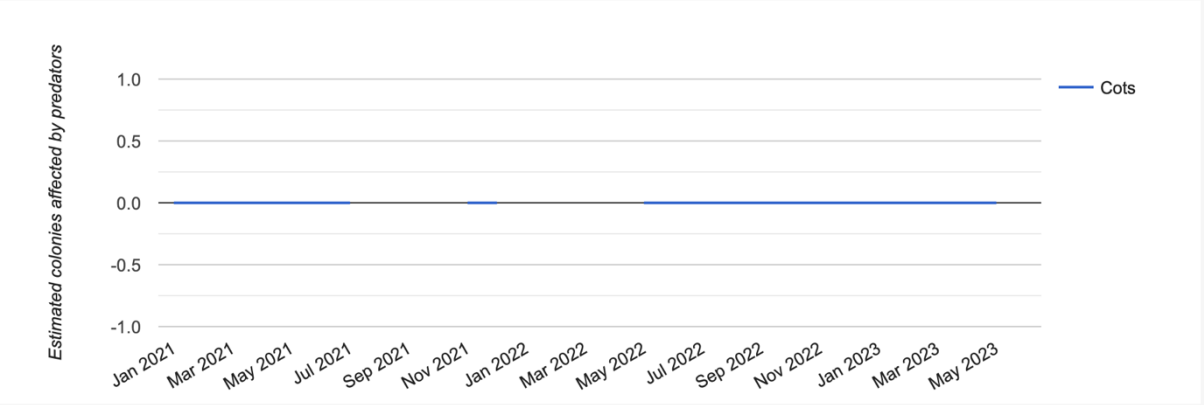
28. *Are there any protocols to safeguard Traditional Owner Knowledge?*
    a. If yes, **mark those that apply**..……..……..……..……25-27 then 29
        i. Memorandum of Understanding
        ii. Non-Disclosure Agreement
        iii. Legal Contract negotiating benefits for all parties
    b. If no ……..…29

29. *What is the level of engagement with Yirrganydji (Traditional Owners) in potential site stewardship project?*
    a. Leading or co-leading ……**YES**…….30
    b. Involved and engaged, mark all
        i. Decision making……Yes / No
        ii. Planning ……Yes / No
        iii. In-water activity ……Yes / No
        iv. Training..……Yes / No
        v. Employment ……..Yes / No……30
    c. Contacted and given consent ……**YES**……...30

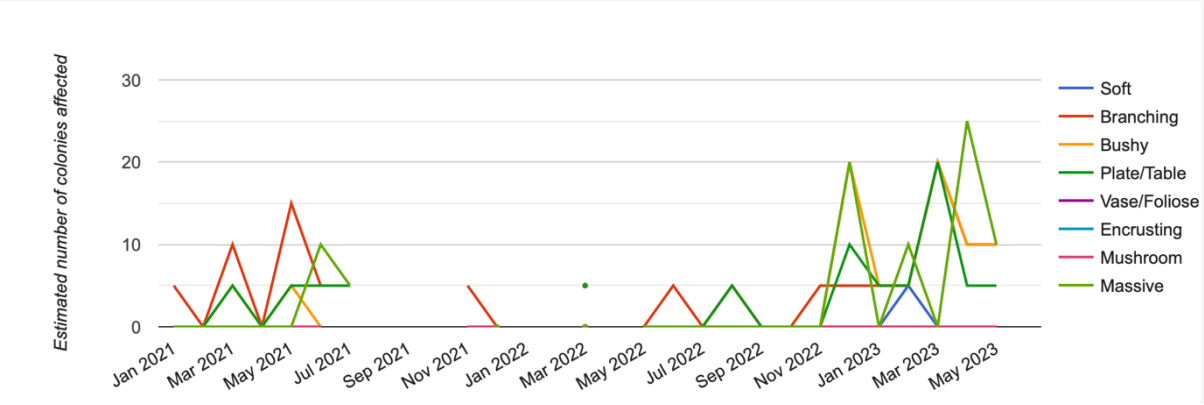
Biological Indicators

30. *Has Eye on the Reef Tourism Weekly Surveys been conducted at the reef site?*
    a. If yes……31
    b. If no ……..……...…….37

31. *Has there been past evidence of **crown-of-thorns starfish (CoTS)** outbreaks at the reef site?*
    a. If yes…….57
    b. If no ……..……...…….32



32. *Has there been past evidence of **severe storm damage** (> 40 colonies) at the reef site?*
    a. If yes…….65
    b. If no ……..……...…….33



33. *Has there been past evidence of **mass coral bleaching** (> 40 colonies) at the reef site?*
    a. If yes…….43
    b. If no ……..……...…….34

34. *Has there been past evidence of **coral disease** outbreaks (> 40 colonies) at the reef site?*
    a. If yes…….43
    b. If no ……..……...…….35

35. *Has there been past evidence of **Drupella snail** outbreaks (> 40 colonies) at the reef site?*
    a. If yes…….61
    b. If no ……..……...…….36

36. *Has Reef Health Impact Surveys (RHIS) or Eye on the Reef Photo-point been conducted at the reef site?*
    a. If yes…….39
    b. If no ……..……...…….37

37. *Have other monitoring methodologies for example, Reef Check been conducted at the reef site?*
    a. If yes…….39
    b. If no ……..……...…….38

38. *Has the Kulbul complimentary site methodology (Appendix A) been conducted at reef site?*
    a. If yes…….39
    b. If no ……...…. **see methodology (Appendix A)**

39. *Is **Live Coral** the dominant benthos category at the reef site?*

    a. If yes……..…45

    b. If no …….40

40. *Is **Live Coral Rock** the dominant benthos category at the reef site?*

    a. If yes……45

    b. If no …….41

41. *Is **Rubble** the dominant benthos category at the reef site?*

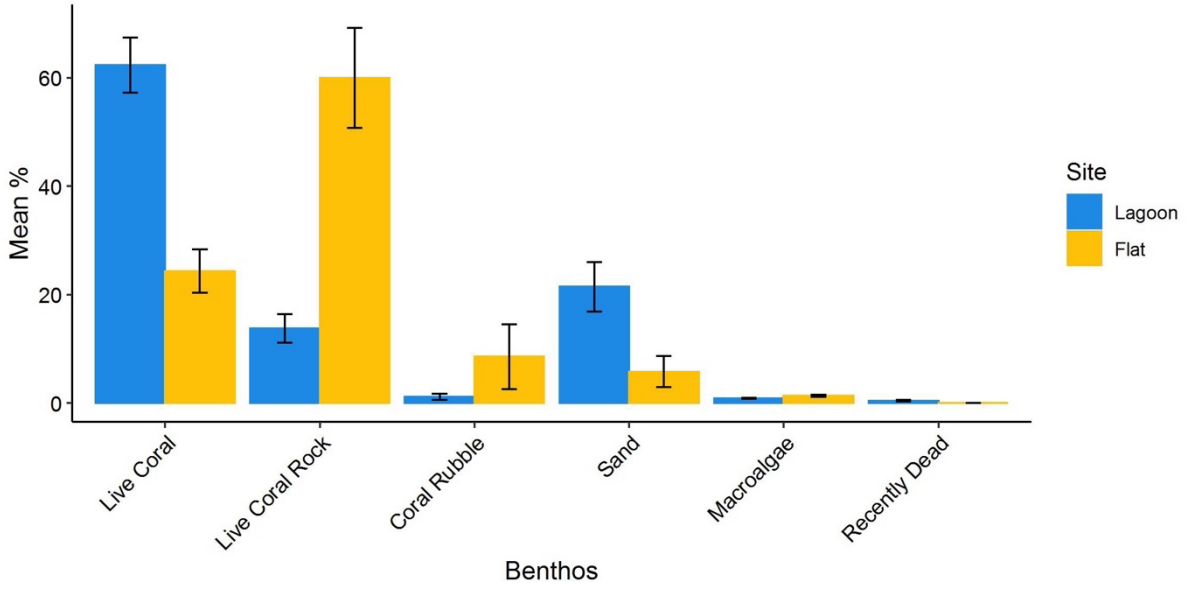
    a. If yes…….65

    b. If no ……...…….……42

42. *Is **Macroalgae** the dominant benthos category at the reef site?*

    a. If yes…….70

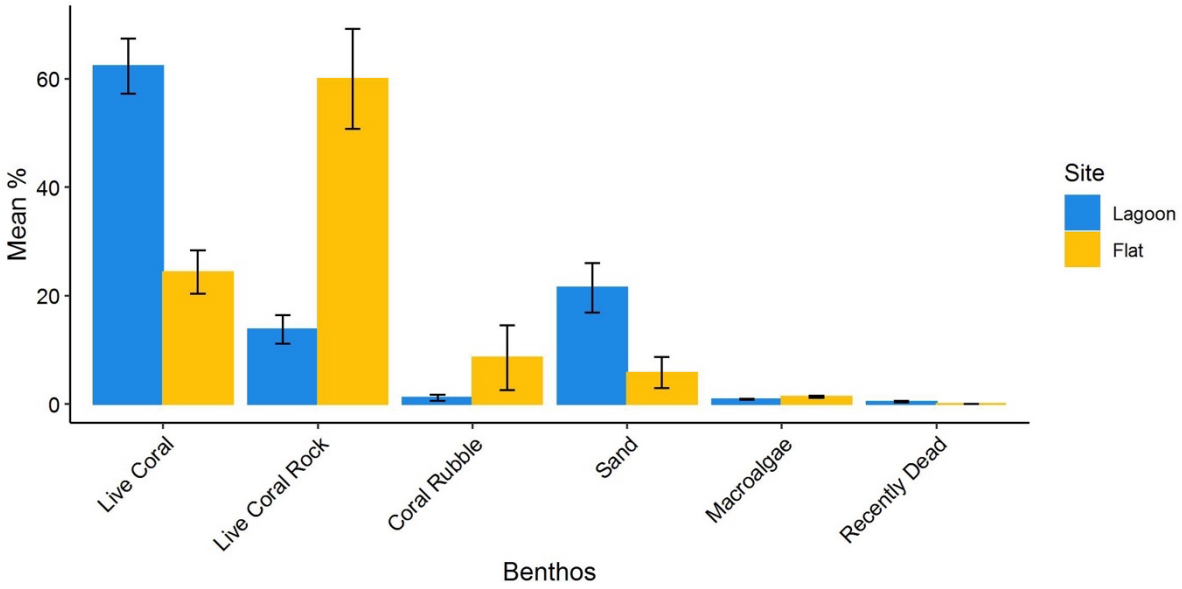
    b. If no …….43



43. *Is **Recently Dead Coral** the dominant benthos category at the reef site?*

a. If yes……45

b. If no ……44



44. *Is **Sand** the dominant benthos category at the reef site?*

a. If yes……72

b. If no ……45

45. *Is the percentage of live coral at the reef site greater than 30%?*

a. If yes……46

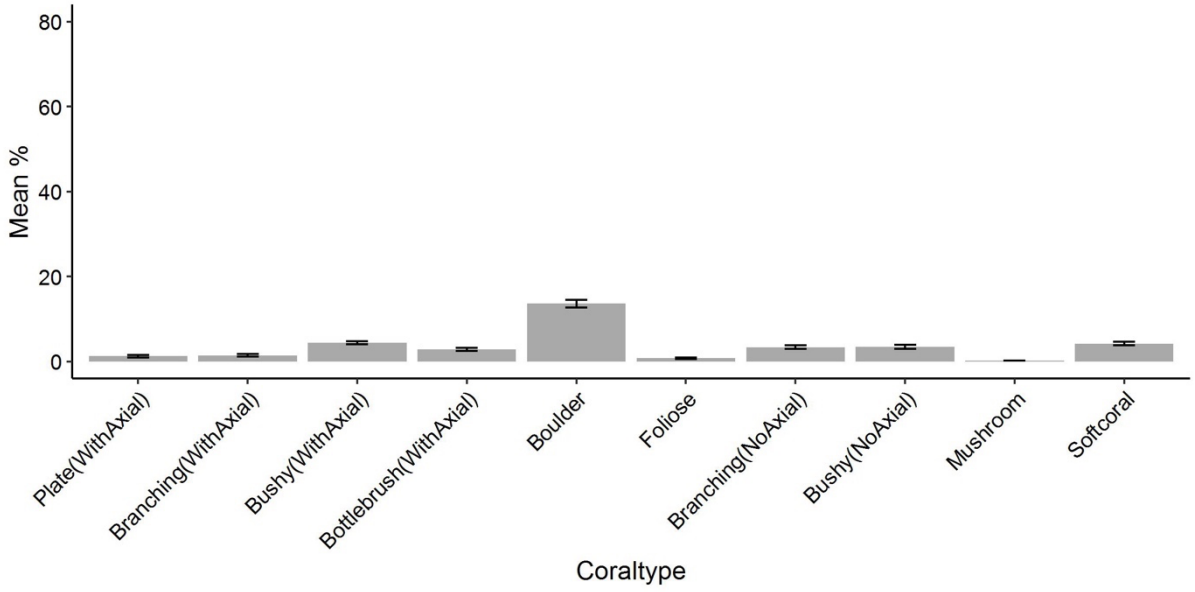
b. If no……..65

46. *Does the dominant coral group at the site have an axial polyp?*

a. If yes……47

b. If no ……48

c. If unknown……..**see methodology (Appendix A)**



For this example and we are going that the combined corals with Axial polyps are greater than the bolder corals. The graph does show a good diversity in coral forms at the Saxon Reef site.

47. *What is the dominant coral group at the reef site?* ……49

a. Plate

b. Branching

c. Bushy

d. Bottlebrush

48. *What is the dominant coral group at the reef site?*

    a. Boulder
    b. Foliose
    c. Branching (no axial polyp)
    d. Bushy (no axial polyp)
    e. Mushroom
    f. Soft coral
    g. **Consider site assisted recovery actions technique to increase coral diversity and resilience**……...……..65 or 70

Natural Resilience Indicators

49. *Have these corals broadcast spawned in recent years at the reef site?*

    a. If yes……50

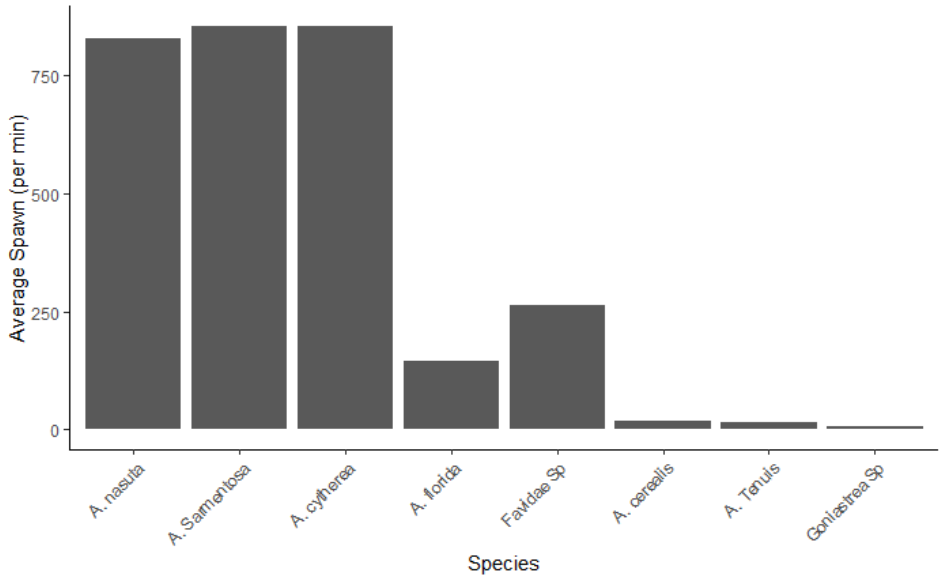
    b. If no……...……...51

50. *Was the rate of coral spawning greater than 250 eggs/minute for most species?*

    a. If yes…..……**A potential good site for coral spawn catching to rear and seed larvae for other locations** ……...…….51

    b. If no……..…..……..51

    c. If unknown……..**see methodology (Appendix B)**



All the species captured spawning Nov 2021 at Saxon Reef, except for Favidae and Goinastrea species were corals with axial polyps.

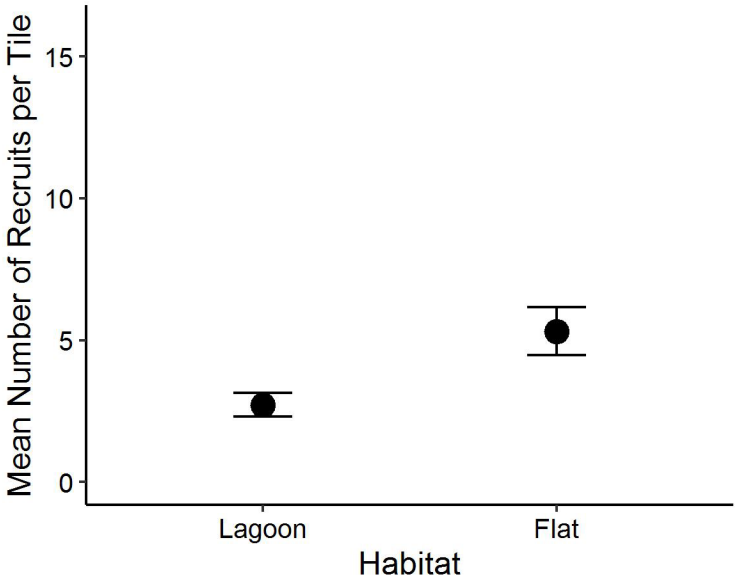
51. *Was there coral recruitment noticed on settlement tiles at the reef site?*

    a. If yes……52

    b. If no……...……..54 or 55

    c. If unknown…….. **see methodology (Appendix C)**

52. *Was the mean number of coral recruits greater then 40 recruits/tile at the reef site?*
    a. If yes……53
    b. If no ……70



In comparison of reef habitats, there was higher recruitment on the reef flat compared to the lagoon.

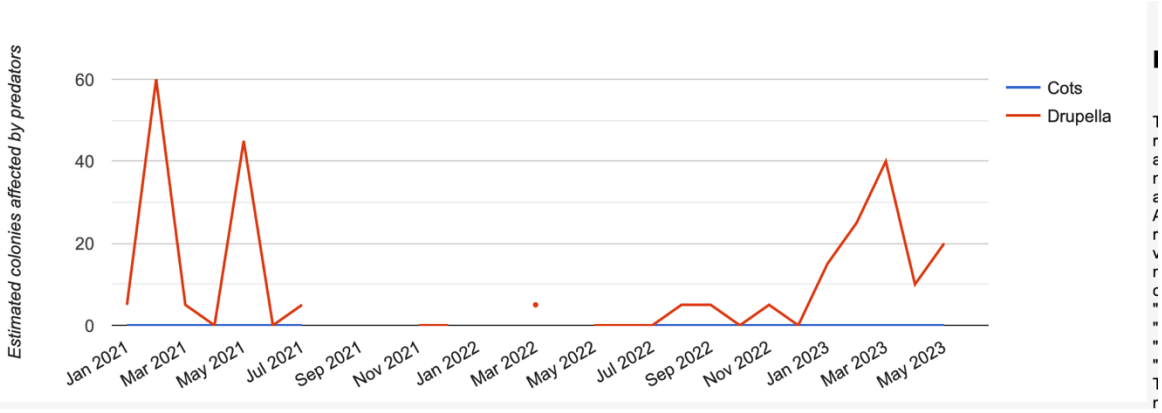
53. *Are the broadcast spawning recruits greater than 50% of the recruitment assemblage (tiles) at the reef site?*
    a. If yes…..... **The site does not require site assisted recovery actions**……71
    b. If no……70

54. *Are coral predators present at the reef site?*

a. If yes for crown-of-thorns starfish (CoTS)……...57

b. If yes for Drupella snails……..61

c. If no……..…55

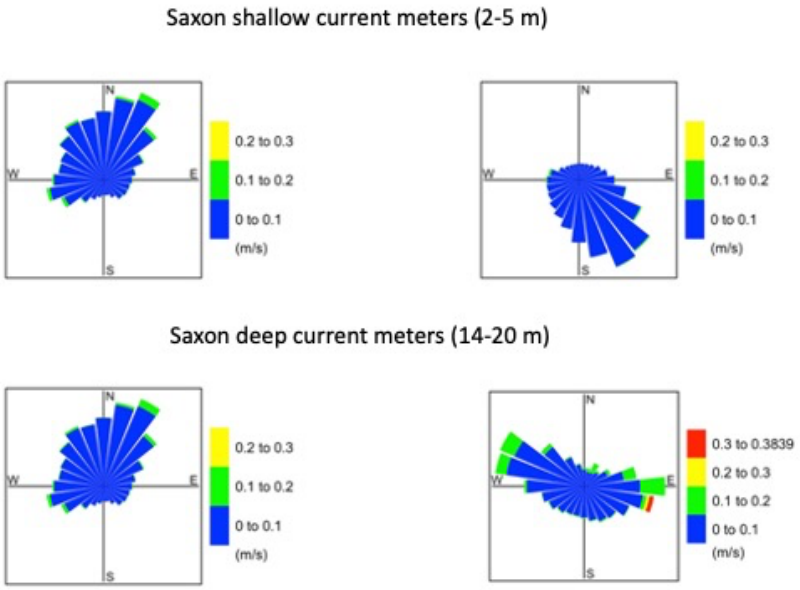


55. *Does the reef site experience flow patterns more than 0.3m/s?*

a. If yes…… **The site has the capacity to recover from heat stress continue with appropriate site assisted recovery techniques.**

b. If no……56

c. If unknown……..…… **see methodology (Appendix D)**



Saxon Reef experiences higher current flows down deep compared to the shallows and they can be bimodal indicating tidal flushing of lagoon.

56. *Are there large schools of planktivores regularly (tidal) observed at the reef site?*
    a. If yes…… **The site potentially has the capacity to recover from heat stress continue with appropriate site assisted recovery techniques.**
    b. If no…… **Emphasise caution if proceeding with site assisted recovery techniques and research potential cooling and shading techniques to mediate heat stress.**

Site Stewardship Recommendations

57. *Is the density of crown-of-thorn starfish (CoTS) > 2 individuals per hectare?*
    a. If yes…….58
    b. If no ……...….32 or 55
    c. If unknown……...38

58. *Is there regular crown-of-thorn starfish (CoTS) control programs at the reef site?*
    a. If yes…….60
    b. If no……..**Consider implementing a control program**……...59

59. *Is there Traditional Owner Ecological Knowledge of crown-of-thorns starfish (CoTS) that can be incorporated into control and interpretation programs?*
    a. If yes……..**Discuss protocols to safeguard Traditional Owner Ecological Knowledge (Appendix E)**……45
    b. If no…….45

60. *Are Traditional Owners involved in crown-of-thorn starfish (CoTS) control programs at the reef site?*
    a. If yes…….59
    b. If no……..**Consider capacity training programs or initiatives…**…..45

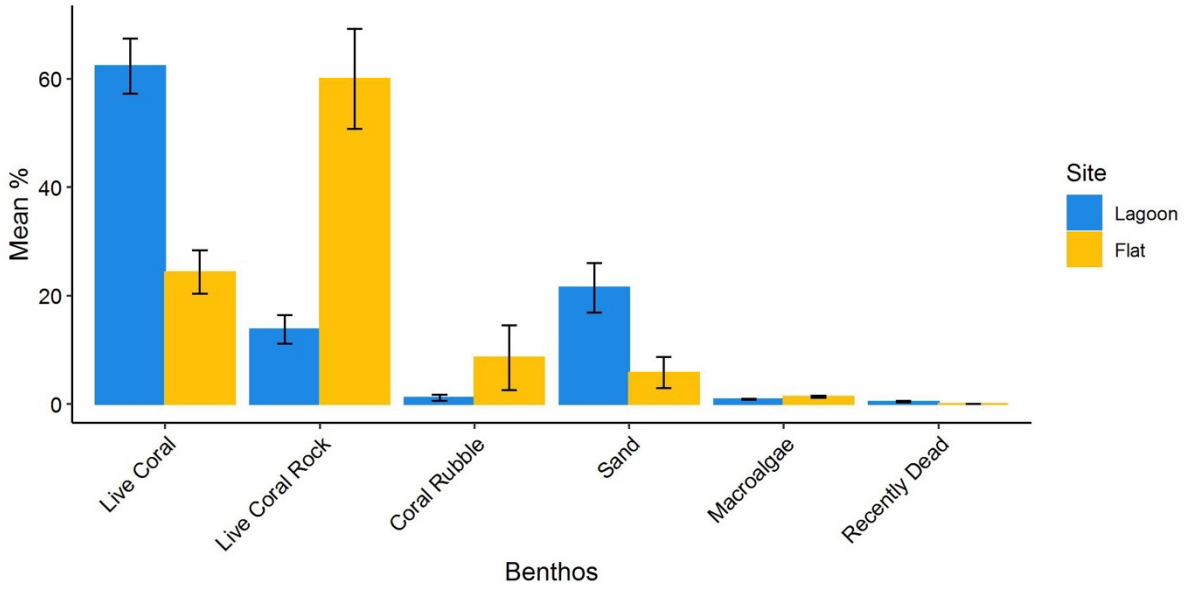
61. *Is the density of Drupella snails greater than 200 individuals per hectare?*
    a. If yes…….62
    b. If no……...….36 or 55
    c. If unknown……...38

62. *Is there regular Drupella snails control programs at the reef site?*
    a. If yes…….63
    b. If no……**Consider implementing a control program**…….45

63. *Is there Traditional Owner Ecological Knowledge of Drupella snails that can be incorporated into control and interpretation programs?*
    a. If yes……...**Discuss protocols to safeguard Traditional Owner Ecological Knowledge (Appendix E)**……45
    b. If no……45

64. *Are Traditional Owners involved in Drupella snail control programs at the reef site?*
    a. If yes……62
    b. If no…….. **Consider capacity training programs or initiatives**…….45

65. *Is the percentage of rubble at the reef site greater than 10%?*
    a. If yes……66
    b. If no……42
    c. If unknown……...36



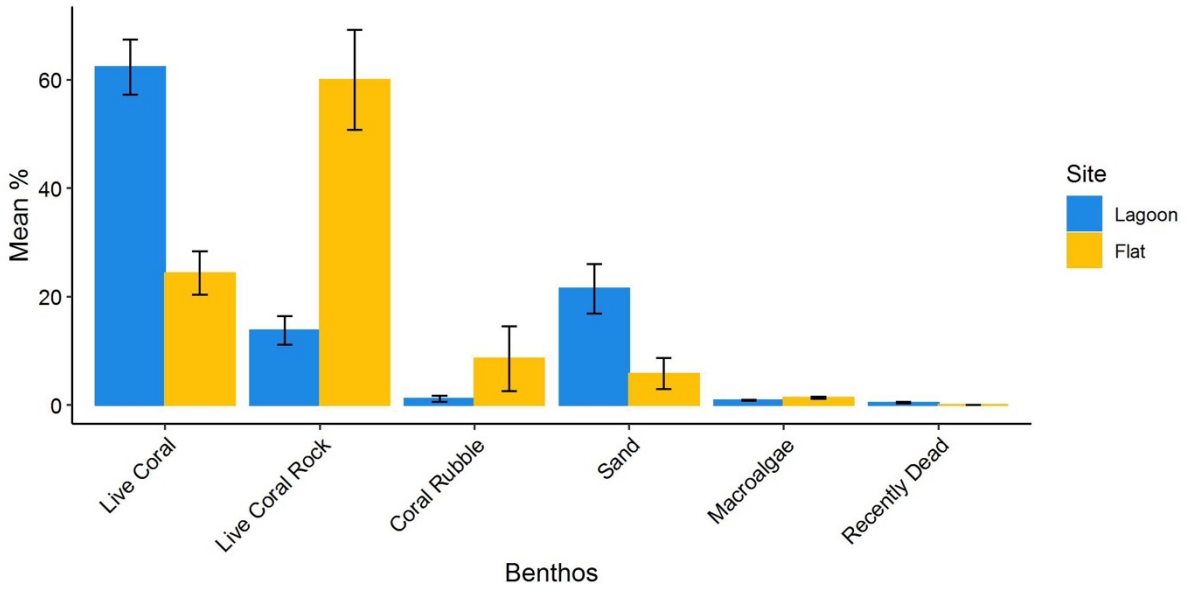
66. *Is the rubble patch at the reef site greater than 50m^2?*
    a. If yes……**Consider coral rubble stabilisation project with Mars Assisted Reef Restoration system or an alternative proven method**……67
    b. If no……42

67. *Are grazing herbivores present at the reef site?*
    a. If yes……**Rubble stabilisation projects require less maintenance**…….68
    b. If no.…….……...…….....68

68. *Is there Traditional Owner Ecological Knowledge of severe storm damage and recovery patterns that can be incorporated into site assisted recovery actions?*
    a. If yes……..… **Discuss protocols to safeguard Traditional Owner Ecological Knowledge (Appendix E)**……....69
    b. If no……..69

69. *Are there coral fragments of opportunity greater than 0.5 per m^2 at the reef site?*
    a. If yes……**Continue with site assisted recovery techniques**…….70
    b. If no……..**Consider collection of coral fragments from other reefs, check the Reef Authority translocation guidelines** or ……72

70. *Is the live coral rock greater than 20% at the reef site and covered in thick turfing algae mats or other macroalgae?*
    a. If yes……**Consider macroalgae removal techniques prior to larval seeding or coral out planting techniques using coral clips**……..……71
    b. If yes (with no macroalgae)……. **Consider coral larval seeding techniques or coral out-planting with coral clip**……71
    c. If no……..36



Live coral rock greater than 20% on the reef flat, where the lagoon was less than 20%

71. *Is there Traditional Owner Ecological Knowledge of coral spawning and connectivity that can be incorporated into site assisted recovery actions?*
    a. If yes……..**Discuss protocols to safeguard Traditional Owner Ecological Knowledge (Appendix E)**…….....54
    b. If no…….55

72. *Are there sufficient sandy patches to place in a moored coral nursery at the reef site?*
    a. If yes……..**Consider Coral Nurture nurseries or Reef Restoration Trees** ……....……...….45 or 54
    b. If no…… **Consider collection of coral fragments from other reefs, check The Reef Authority translocation guidelines**…..……..……45 or 54

Norman Reef – site stewardship plan

The Yirrganydji people are the traditional custodians of Norman Reef and have related to Norman in the past (pre-European) and present. This Sea Country has animals of cultural significance, and the reef was visited seasonally via seasonal indicators. The Yirrganydji have been actively involved in the planning management of Norman Reef with a Traditional Use of Marine Resource Agreement (TUMRA) with The Great Barrier Reef Marine Park Authority. The Yirrganydji people through Dawul Wuru Aboriginal Corporation manage a Land and Sea Country Ranger program that visits Norman Reef. At this reef they have been involved in monitoring, compliance, pest management, education and work experience programs.

The tourism operator Reef Magic/Dreamtime acknowledge and recognises the Yirrganydji people as the Traditional Custodians of Norman Reef. This has allowed a partnership to develop where we regularly contact Yirrganydji for consent to carry out activities on their Sea Country. Yirrganydji Traditional Owner knowledge and values have been incorporated into our education and interpretation programs which was safeguarded through a Memorandum of Understanding between the parties.

Overall, the Norman Reef site had high live coral with a mean coverage of 50% with reasonable diversity and abundance in all coral groups including the fast-growing reef building branching corals the Acroporidae. However, the dominant coral group was the boulder corals, and we suggest increasing overall resilience of the site through site assisted recovery actions. There are large coral rubble areas potentially suitable for coral rubble stabilisation using the Mars Assisted Reef Restoration System (MARRS). The Reef Stars require coral fragments of opportunity which are in high abundance at Norman Reef. In addition, the large areas of live coral rock on the reef flat are suitable for coral larval seeding. Moreover, the site had low risk from coral predators and there were regular deep water current flows that could potentially alleviate coral heat stress during marine heatwaves.

Through the Kul-bul Decision Tree, GBR Biology, Reef Restoration Foundation and the Dawul Wuru Aboriginal Corporation identified that the Norman Reef site could benefit from site assisted recovery actions. Eye on the Reef and Kul-bul monitoring methods were used to

determine current reef health. Further it is possible to incorporate Traditional Owner Ecological Knowledge into future projects and such projects to be co-designed and managed with the Yirrganydji people.

Working Decision Tree Example (Norman Reef)

Cultural Awareness

1. *Who are the Traditional Owners that have connection to **Norman Reef**.*
    a. Name: **The Yirrganydji People**……..... 2
    b. If unknown contact North Queensland Land Council, Great Barrier Reef Marine Park Authority, Great Barrier Reef Foundation or Queensland Parks and Wildlife Service & Partnerships…..……... 2

2. *Have the Traditional Owners visited, access or used the reef/reef site in the past?*
    a. If yes……...4
    b. If no…..…….……...…..…7

3. *Do the Traditional Owners visit, access or use the reef/reef site today?*
    a. If yes…….11
    b. If no…..…….……...……..7

4. *Does the reef/reef site have animals of cultural significance to the Traditional Owners?*
    a. If yes……...5
    b. If no…..…….……...……..6

5. *Was the reef/reef site visited seasonally by the Traditional Owners and was use governed by Seasonal Indicators?*
    a. If yes……...6
    b. If no…..…….……...……..6

6. *Does the reef/reef site have ceremonial cultural significance to the Traditional Owners?*
    a. If yes……...3
    b. If no…..……..……...……..3

7. *Do the Traditional Owners not visit the reef/reef site due to limited access?*
    a. If yes…….21
    b. If no…..……..……...……..8

8. *Do the Traditional Owners not visit the reef/reef Site due to resources?*
    a. If yes…….21
    b. If no…..……..……...……..9

9. *Do the Traditional Owners not visit the reef/reef site due to historical reasons?*
    a. If yes…….21
    b. If no…..……..……...……10

10. *Do the Traditional Owners not visit the reef/reef site due to cultural reasons?*
    a. If yes…….11
    b. If no…..……..……...……11

11. *Are the Traditional Owners involved in **planning** management at the reef/reef site?*
    a. If yes…….12
    b. If no…..……..……...……18

12. *Do the Traditional Owners have any Indigenous Protected Areas (IPA's) within reef/reef site?*
    a. If yes…….13
    b. If no…..……..……...……13

13. *Does the Traditional Owners have Traditional Use Marine Resources Agreement (TUMRA) place at reef/reef site?*
    a. If yes……14
    b. If no…..……..……..…..14

14. *Does the Traditional Owners have a Land and Sea Ranger Program?*
    a. If yes……15
    b. If no…..……..……..18

15. *Are the Traditional Owners involved in **monitoring** practices at the reef/reef site?*
    a. If yes……16
    b. If no…..……..……...……16

16. *Are the Traditional Owners involved in **compliance** practices at the reef/reef site?*
    a. If yes……17
    b. If no…..……..……...……17

17. *Are the Traditional Owners involved in **pest management** practices at the reef/reef site?*
    a. If yes……18
    b. If no…..……..……...……18

18. *Are the Traditional Owners involved in **events** at the reef/reef site?*
    a. If yes……19
    b. If no…..……..……...……19

19. *Are the Traditional Owners involved in **education/interpretation** programs at the reef/reef site?*
    a. If yes……20
    b. If no…..……..……...……20

20. *Are the Traditional Owners involved in **work experience** programs at the reef/reef site?*
    a. If yes……22
    b. If no…..……..……...……22

Cultural Engagement

21. *Do you facilitate visits to Country for Traditional Owners?*
    a. If yes……..……22
    b. If no…..……...……11

22. *Are the Traditional Owners acknowledged during reef site visits?*
    a. If yes…….23
    b. If no…**Discuss protocols with Traditional Owners to deliver acknowledgment.**

23. *Have you contacted the Traditional Owners and asked for consent in conducting activities on their Country?*
    a. If yes ……24
    b. If no……**Outline your activities to the Traditional Owners and ask about protocols to gain consent**……24

24. *Are Traditional Owner knowledge and values incorporated into your own* ***education/interpretation*** *activities?*
    a. If yes…….28
    b. If no…..……...……25

25. *Are* ***Traditional Owner knowledge*** *and values incorporated into your own* ***sales/business*** *activities?*
    a. If yes…….28
    b. If no…..……...……26

26. *Are Traditional Owner knowledge and values incorporated into your own* ***monitoring*** *activities?*
    a. If yes…….28
    b. If no…..……...……27

27. *Is Traditional Owner knowledge and values incorporated into your own **site stewardship or reef management** activities?*
    a. If yes……28
    b. If no…..……..……..……29

28. *Are there any protocols to safeguard Traditional Owner Knowledge?*
    a. If yes, **mark those that apply**..……..……..……..……25-27 then 29
        i. Memorandum of Understanding
        ii. Non-Disclosure Agreement
        iii. Legal Contract negotiating benefits for all parties
    b. If no ……..…29

29. *What is the level of engagement with Yirrganydji (Traditional Owners) in potential site stewardship project?*
    a. Leading or co-leading ……**YES**…….30
    b. Involved and engaged, mark all
        i. Decision making……Yes / No
        ii. Planning ……Yes / No
        iii. In-water activity ……Yes / No
        iv. Training..……Yes / No
        v. Employment ……..Yes / No……30
    c. Contacted and given consent ……**YES**……...30

Biological Indicators

30. *Has Eye on the Reef Tourism Weekly Surveys been conducted at the reef site?*
    a. If yes…….31
    b. If no ……..……...…….37

31. *Has there been past evidence of **crown-of-thorns starfish (CoTS)** outbreaks at the reef site?*
    a. If yes…….57
    b. If no ……..……...…….32

32. *Has there been past evidence of **severe storm damage** (> 40 colonies) at the reef site?*
    a. If yes…….65
    b. If no ……..……...…….33

33. *Has there been past evidence of **mass coral bleaching** (> 40 colonies) at the reef site?*
    a. If yes…….43
    b. If no ……..……...…….34

34. *Has there been past evidence of **coral disease** outbreaks (>40 colonies) at the reef site?*
    a. If yes…….43
    b. If no ……..……...…….35

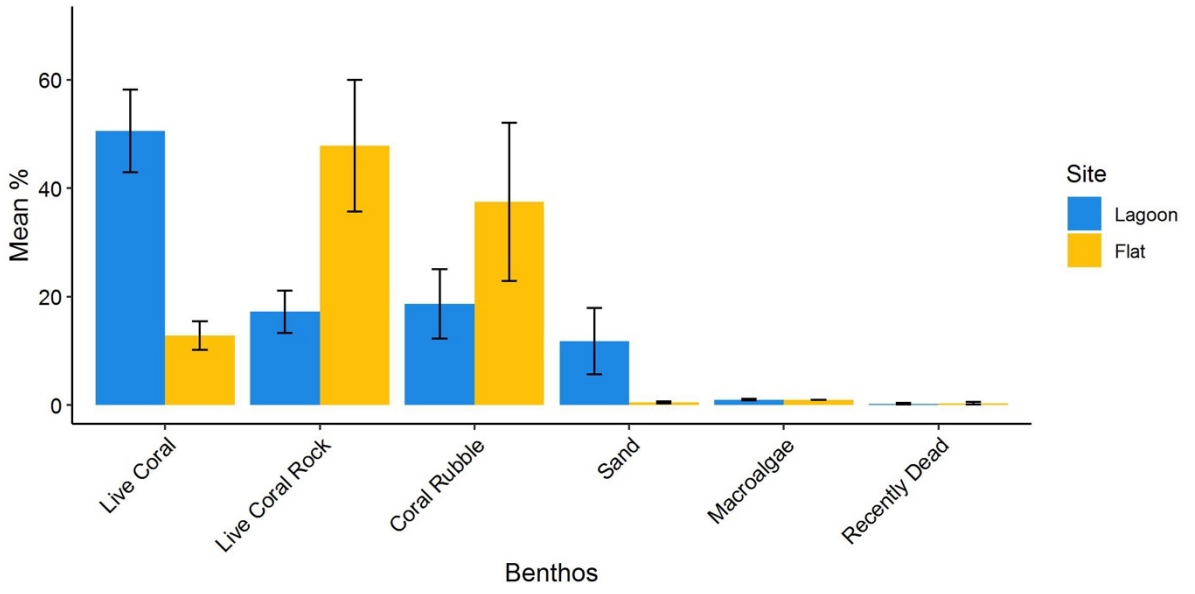
35. *Has there been past evidence of **Drupella snail** outbreaks (> 40 colonies) at the reef site?*
    a. If yes…….61
    b. If no ……..……...…….36

36. *Has Reef Health Impact Surveys (RHIS) or Eye on the Reef Photo-point been conducted at the reef site?*
    a. If yes……39
    b. If no ……..……...…….37

37. *Have other monitoring methodologies for example, Reef Check been conducted at the reef site?*
    a. If yes…….39
    b. If no ……..……...…….38

38. *Has the Kulbul complimentary site methodology (Appendix A) been conducted at reef site?*
    a. If yes…….39
    b. If no ……..…. **see methodology (Appendix A)**

39. *Is **Live Coral** the dominant benthos category at the reef site?*
    a. If yes……..…45
    b. If no …….40



40. *Is **Live Coral Rock** the dominant benthos category at the reef site?*
    a. If yes……45
    b. If no ……41

41. *Is **Rubble** the dominant benthos category at the reef site?*
    a. If yes……65
    b. If no ……...……..…….42

42. *Is **Macroalgae** the dominant benthos category at the reef site?*
    a. If yes……70
    b. If no ……43

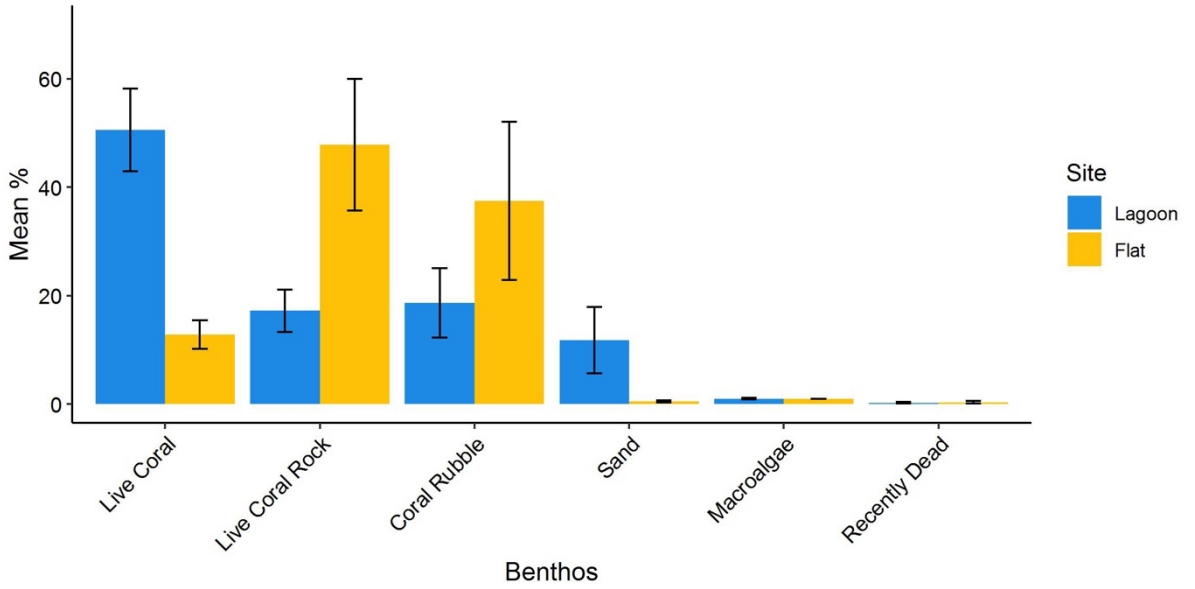
43. *Is **Recently Dead Coral** the dominant benthos category at the reef site?*
    a. If yes……45
    b. If no ……44

44. *Is **Sand** the dominant benthos category at the reef site?*
    a. If yes……72
    b. If no ……45

45. *Is the percentage of live coral at the reef site greater than 30%?*

a. If yes……46

b. If no……..65

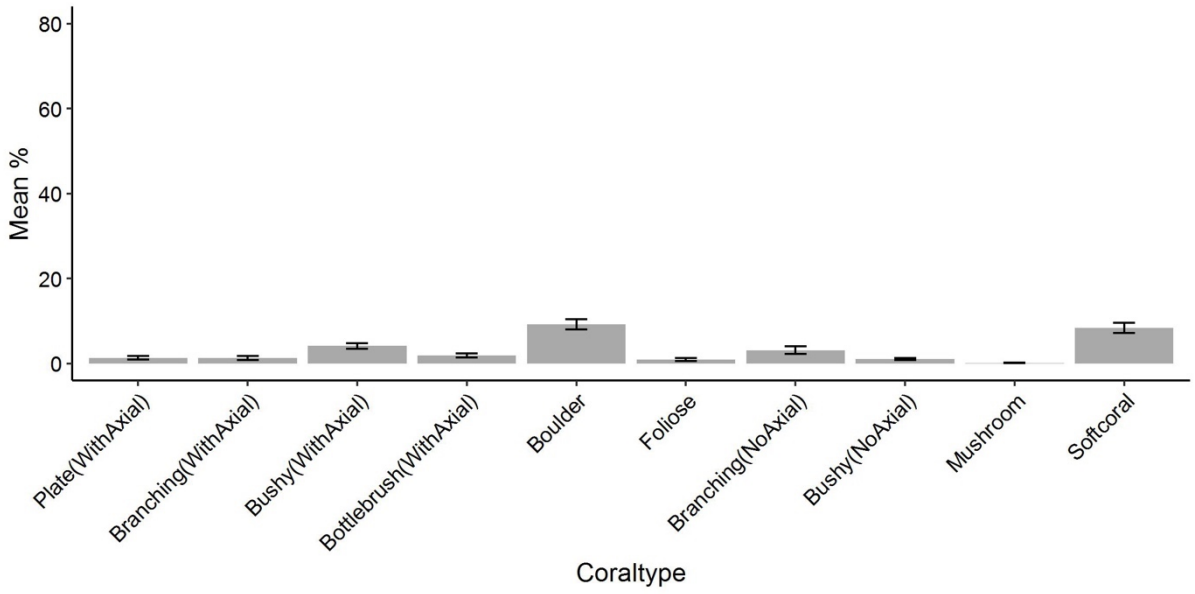


46. *Does the dominant coral group at the site have an axial polyp?*

a. If yes……47

b. If no ……48

c. If unknown……...**see methodology (Appendix A)**



47. *What is the dominant coral group at the reef site?* ……..49

a. Plate
b. Branching
c. Bushy
d. Bottlebrush

48. *What is the dominant coral group at the reef site?*

a. Boulder
b. Foliose
c. Branching (no axial polyp)
d. Bushy (no axial polyp)
e. Mushroom
f. Soft coral
g. **Consider site assisted recovery actions technique to increase coral diversity and resilience**……...……..65 or 70

Natural Resilience Indicators

49. *Have these corals broadcast spawned in recent years at the reef site?*
    a. If yes……50
    b. If no……...……...51

50. *Was the rate of coral spawning greater than 250 eggs/minute for most species?*
    a. If yes…..……**A potential good site for coral spawn catching to rear and seed larvae for other locations** ……...…….….51
    b. If no……..…..……..51
    c. If unknown……..**see methodology (Appendix B)**

51. *Was there coral recruitment noticed on settlement tiles at the reef site?*
    a. If yes……52
    b. If no……...……..54 or 55
    c. If unknown…….. **see methodology (Appendix C)**

52. *Was the mean number of coral recruits greater then 40 recruits/tile at the reef site?*
    a. If yes……53
    b. If no ……70

53. *Are the broadcast spawning recruits greater than 50% of the recruitment assemblage (tiles) at the reef site?*
    a. If yes…..…**The site does not require site assisted recovery actions**……71
    b. If no.……70

54. *Are coral predators present at the reef site?*
    a. If yes for crown-of-thorns starfish (CoTS)……...57
    b. If yes for Drupella snails……..61
    c. If no……..…55

0 CoTS found in 0.11 hectares surveyed.

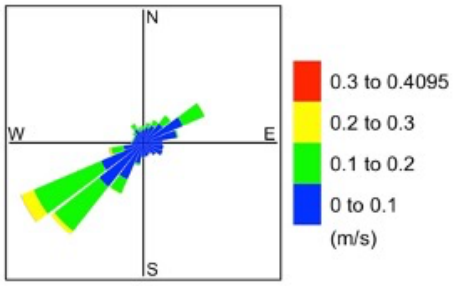
55. *Does the reef site experience flow patterns more than 0.3m/s?*

a. If yes…… **The site has the capacity to recover from heat stress continue with appropriate site assisted recovery techniques.**

b. If no…….56

c. If unknown……..…… **see methodology (Appendix D)**

Norman Reef deep current meter (20 m)



Norman Reef experiences higher current flows down deep, though current meters in the shallows had technical difficulties and were not able to record.

56. *Are there large schools of planktivores regularly (tidal) observed at the reef site?*

a. If yes…… **The site potentially has the capacity to recover from heat stress continue with appropriate site assisted recovery techniques.**

b. If no…… **Emphasise caution if proceeding with site assisted recovery techniques and research potential cooling and shading techniques to mediate heat stress.**

Site Stewardship Recommendations

57. *Is the density of crown-of-thorn starfish (CoTS) > 2 individuals per hectare?*
    a. If yes…….58
    b. If no ……...….32 or 55
    c. If unknown……...38

58. *Is there regular crown-of-thorn starfish (CoTS) control programs at the reef site?*
    a. If yes…….60
    b. If no.……..**Consider implementing a control program**……...59

59. *Is there Traditional Owner Ecological Knowledge of crown-of-thorns starfish (CoTS) that can be incorporated into control and interpretation programs?*
    a. If yes……..**Discuss protocols to safeguard Traditional Owner Ecological Knowledge (Appendix E)**……45
    b. If no.…….45

60. *Are Traditional Owners involved in crown-of-thorn starfish (CoTS) control programs at the reef site?*
    a. If yes…….59
    b. If no.……..**Consider capacity training programs or initiatives…**…..45

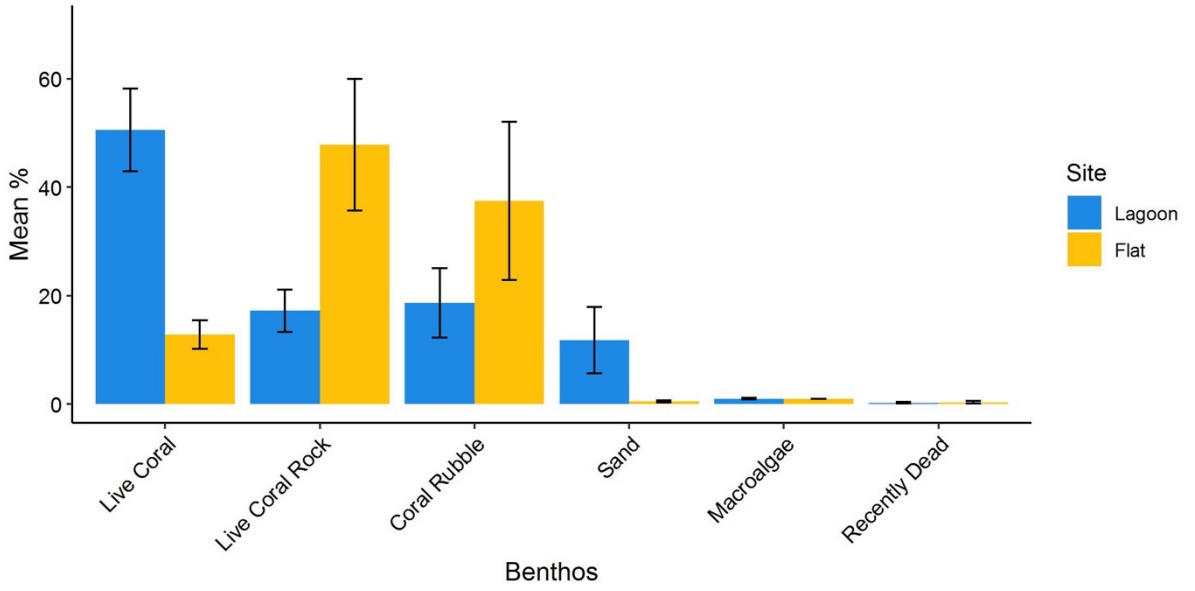
61. *Is the density of Drupella snails greater than 200 individuals per hectare?*
    a. If yes…….62
    b. If no.……...….36 or 55
    c. If unknown……...38

62. *Is there regular Drupella snails control programs at the reef site?*
    a. If yes…….63
    b. If no.……**Consider implementing a control program**…….45

63. *Is there Traditional Owner Ecological Knowledge of Drupella snails that can be incorporated into control and interpretation programs?*
    a. If yes……...**Discuss protocols to safeguard Traditional Owner Ecological Knowledge (Appendix E)**……45
    b. If no……45

64. *Are Traditional Owners involved in Drupella snail control programs at the reef site?*
    a. If yes……62
    b. If no…….. **Consider capacity training programs or initiatives**…….45

65. *Is the percentage of rubble at the reef site greater than 10%?*
    a. If yes……66
    b. If no……..42
    c. If unknown……...36



66. *Is the rubble patch at the reef site greater than 50m^2?*
    a. If yes……**Consider coral rubble stabilisation project with Mars Assisted Reef Restoration system or an alternative proven method**……67
    b. If no……42

There was a rubble patch ~ 350 m^2.

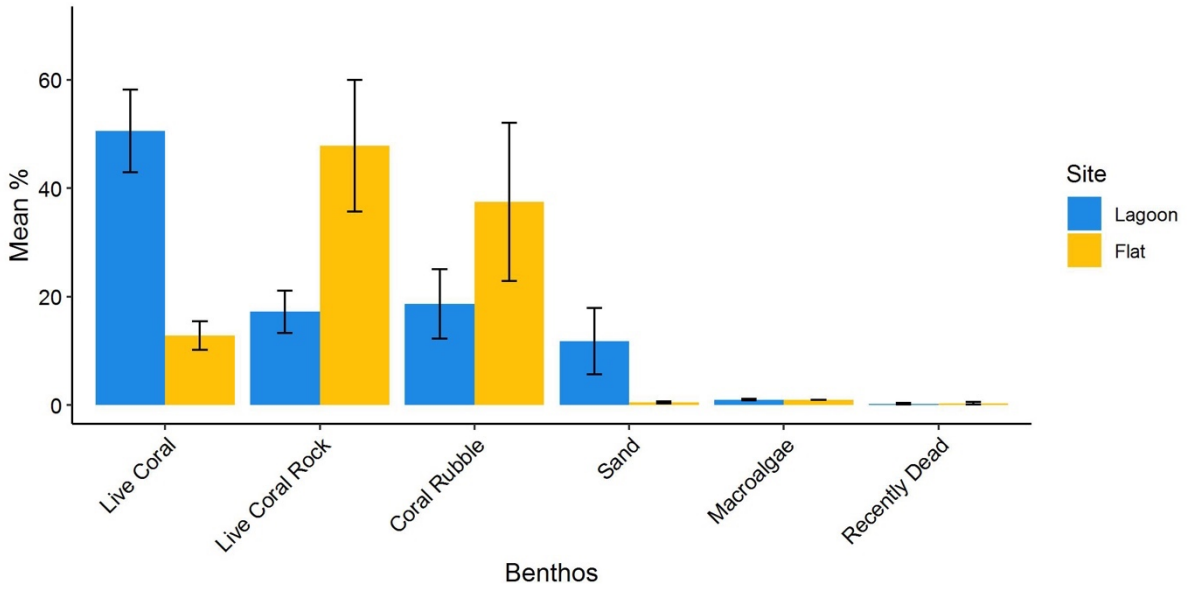
67. *Are grazing herbivores present at the reef site?*
    a. If yes……**Rubble stabilisation projects require less maintenance**…….68
    b. If no……..……..…….....68

68. *Is there Traditional Owner Ecological Knowledge of severe storm damage and recovery patterns that can be incorporated into site assisted recovery actions?*
    a. If yes…… **Discuss protocols to safeguard Traditional Owner Ecological Knowledge (Appendix E)**……....69
    b. If no……..69

69. *Are there coral fragments of opportunity greater than 0.5 per m^2 at the reef site?*
    a. If yes……**Continue with site assisted recovery techniques**…….70
    b. If no……..**Consider collection of coral fragments from other reefs, check the Reef Authority translocation guidelines** or ……72

Fragment density was 0.64 Frags/m^2 (Kul-bul methodology)

70. *Is the live coral rock greater than 20% at the reef site and covered in thick turfing algae mats or other macroalgae?*
    a. If yes……**Consider macroalgae removal techniques prior to larval seeding or coral out planting techniques using coral clips**……..……71
    b. If yes (with no macroalgae)…….. **Consider coral larval seeding techniques or coral out-planting with coral clip**……71
    c. In no……..…36



The reef flat has high percentage of live coral rock compared to the lagoon.

71. *Is there Traditional Owner Ecological Knowledge of coral spawning and connectivity that can be incorporated into site assisted recovery actions?*
    a. If yes……..**Discuss protocols to safeguard Traditional Owner Ecological Knowledge (Appendix E)**…….....54
    b. If no…….54

72. *Are there sufficient sandy patches to place in a moored coral nursery at the reef site?*
    a. If yes……..**Consider Coral Nurture nurseries or Reef Restoration Trees** ……....……...….45 or 54
    b. If no…… **Consider collection of coral fragments from other reefs, check The Reef Authority translocation guidelines**…...…..……45 or 54

Appendix A – Kul-Bul Methodologies

Coral Cover – photo quadrats

Dive method

Camera Settings

Using the Olympus TG5/6, in underwater mode select Underwater Macro. Perform white balance test or setting is on.

Equipment

Prior to entering water, ensure that you have the following equipment:

- Camera
- Transect tape.
- Quadrat
- Slate with pencil

Dive

1) Select site randomly whilst keeping in mind that the transect should be within a 5m depth range. Avoid high surge areas.
2) Lay out the 30m transect.
3) Starting at 0m on the left-hand side of the transect tape a photo is taken. This is repeated every metre, alternating sides until 30 quadrats have been completed. The camera diver will swim above the quadrat holder and divers will swim in parallel. Once the photo is taken and the camera operator is confident in the photo they are to tap the quadrat holder on the head to indicate the photo has been taken.

Photo Criteria

- Quadrat should be held horizontally over the substrate, camera held directly above and in the centre of the quadrat. If the camera is not directly above the quadrat the photo will not show a square quadrat and cropping issues ensue.
- Photos should not include the transect tape or any other equipment.
- Photos taken in a manner to eliminate shadow from camera diver, for example swim towards the sun rather than having the sun behind you.

- When a photo is taken, check the camera display to ensure all the quadrat is inside the photo and angle is correct, there are no bubbles on lens causing distortion and that the photo is in focus.

Photo Editing and Upload

Important to digitally store photos in appropriate labelled folder that includes Date, site and transect number and have an efficient data storage archive.

1) Each photo then needs to be cropped before uploading to CoralNet. Clicking on a photo will open it in the 'Photos' programme, and there is an edit function on the top right of the page. Once in edit, select Crop & rotate.
2) First Change the Aspect ratio to Square.
3) Straighten the photo and crop to remove the quadrat as much as possible.
4) Click the arrow next to save a copy and click save.
5) Once all cropped, highlight all and rename Transect 1. This will name each photo Transect 1 (Number 1-30).
6) Upload to nominated source (need stable internet connection)
7) Upload in the format YYYY/MM/DD_CAPS acronym for reef Transect 1 (Photo Number)
8) If have multiple sites, a recommended tip is to use brief and intelligible reef acronyms.

Coral Net Method

Apply Uniform Settings

Open an image and open the Annotation tool:

1) Click on the “Settings” button found on the top left of the image.
2) In the pop up, select the following:
3) Point marker: Crosshair and circle
4) Point marker size: 12
5) Point marker is scaled: check.
6) Point number size: 28
7) Point number is scaled: check.
8) Show machine annotations: check.
9) Click on the “Save settings” button.
10) Click on the × button on the upper right corner to exit.

This will be saved per user. So will only need to be done once per user profile.

Image Analysis Process

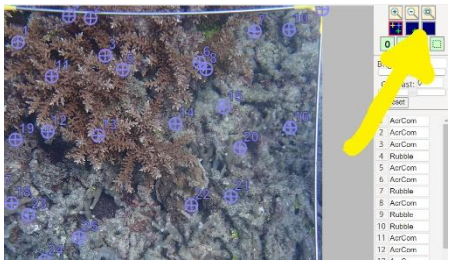
1) Click on the first cell in the ID column found on the far right of the screen.
2) The analysis point (#1) on the image will change to green.
3) Identify the benthic category/label underneath the #1 point’s crosshair.
4) After selecting a category, the cursor will automatically advance to the next point.
5) Repeat steps until all points on the image are classified.
6) Click on “Save Progress” to save your annotations. “ALL DONE” will be displayed at the bottom of the column to indicate that all annotations have been saved and confirmed.
7) Move onto next image.

Easiest way to annotate a lot of images within the same image set/location/date/patch is to search the image set then open tabs of each image. If you simply annotate and click next it will open images not in the initial search.

If struggling to identify the benthos under the crosshair:

1) Left click will zoom in to the image and right click will zoom out.

2) Press the far-right blue button to clear all crosshairs so you can have a better look. If you can identify it, press the far-left blue button to get all crosshairs back. Middle blue button will only show the crosshair currently selected which is handy if the crosshair is on a number.



3) If the whole area under the circle was dark/black use the category Shadow (SHAD), do not assume what is under the crosshair.
4) The category Unclear (UNC) should be used when the nature of the benthos cannot be determined due to image quality i.e. blurry or bubble on lens.
5) Unclear (UNC) can also be used if you don't know what category should be used as it can be searched by someone later. Better to do this than label something incorrectly.
6) If a point falls precisely between benthic categories (e.g., coral-rock), the benthic category occupying the greatest area within the symbol (circle wrapping the crosshairs) will be classified.
7) If the benthic categories occupy an equal space within the symbol, the benthos falling on the top left quadrant within the point symbol will be classified.

See Document “CoralNet Cheat sheet” for photographic examples of each label/benthic category.

Methods derived from:

Lozada-Misa P., B. D. Schumacher, and B. Vargas-Ángel. 2017. Analysis of benthic survey images via CoralNet: a summary of standard operating procedures and guidelines. Pacific Islands Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96818-5007. Pacific Islands Fish. Sci. Cent. Admin. Rep. H-17-02, 175 p. https://doi.org/V5/10.7289/V5/AR-PIFSC-H-17-02.

CoralNet Cheat Sheet

With Kulbul we were interested in coral assemblages that were partitioned into broad morphological groups (Fig. 1). Corals with axial polyps are often associated with fast growing coral reef building coral species. In comparison, corals without axial polyps that which are less known reef builders, however, have other important ecological functions. The same categories and classification used in CoralNet could be applied to other artificial intelligence software such as Reef Cloud.

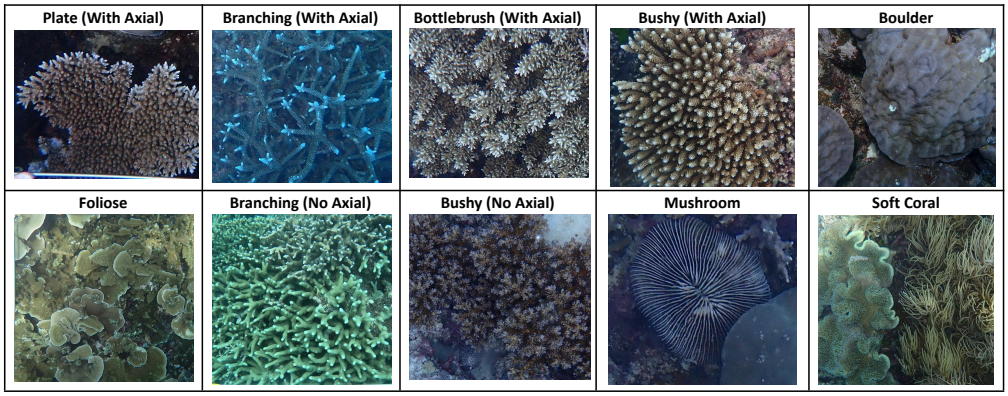
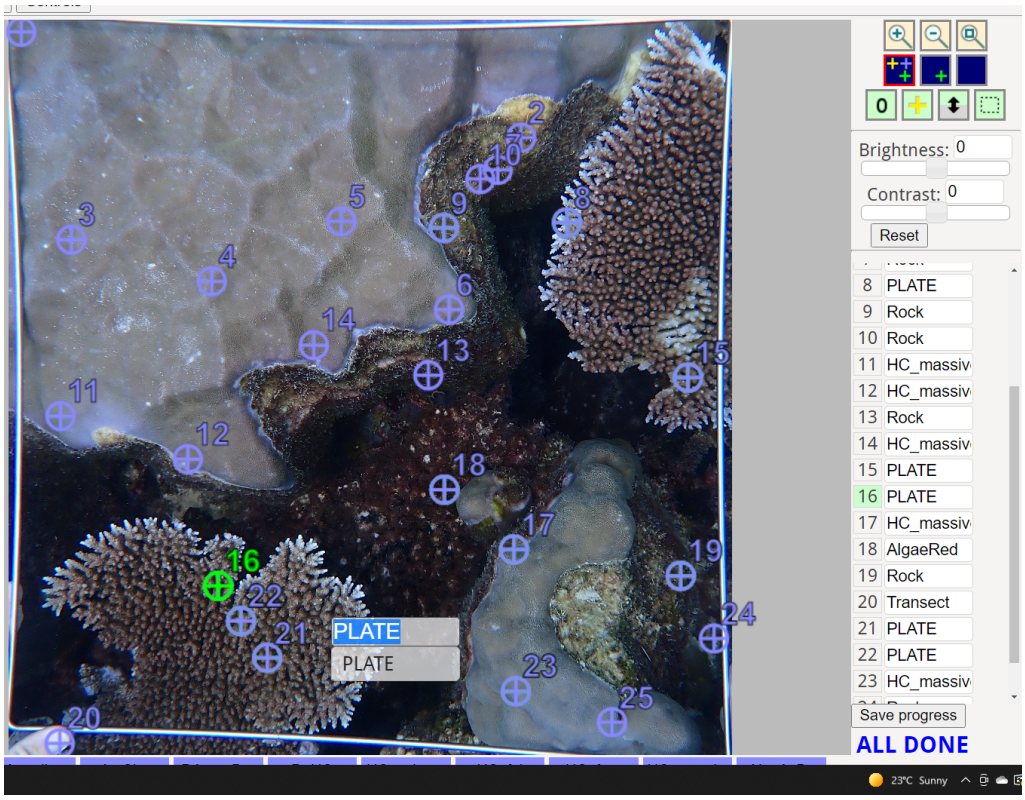


Fig. 1. Specified morphological coral groups for the Kul-Bul project

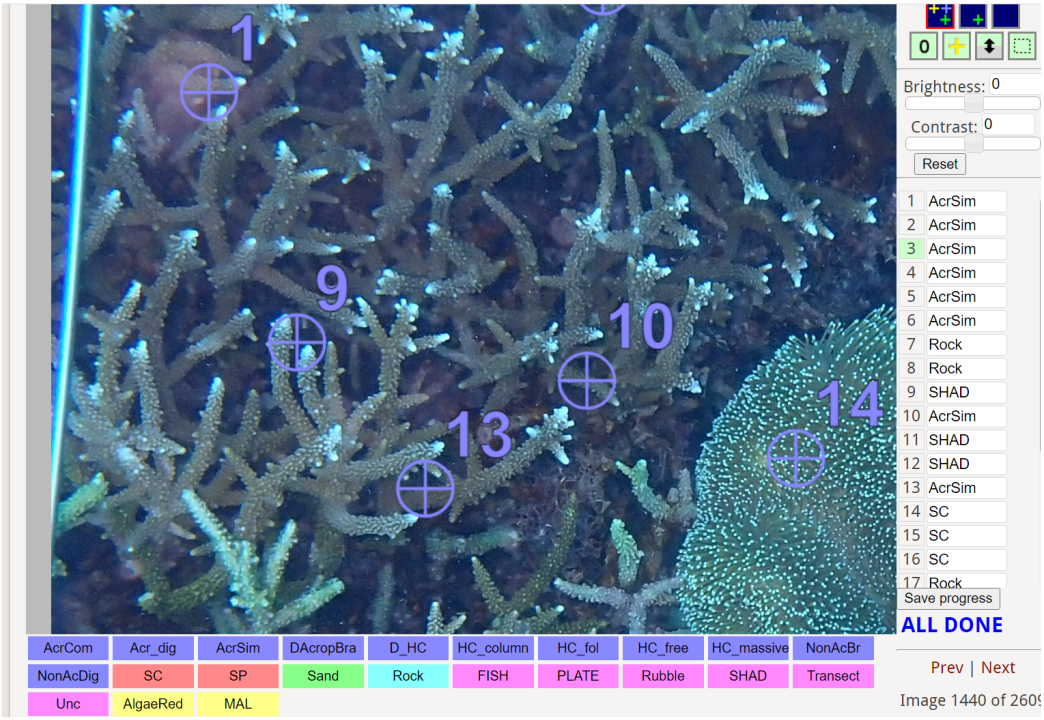
The section below outlines the labels used in CoralNet to match the coral assemblage questions we were asking.

Coral colonies with axial polyps

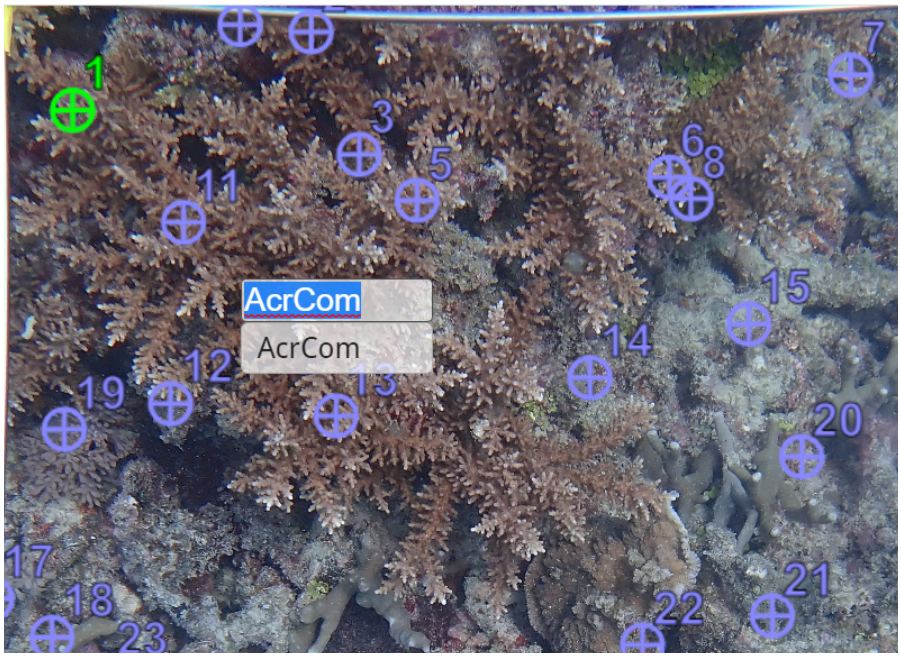
PLATE (Acropora plate) label defines growth as predominantly horizontal rather than bushy.

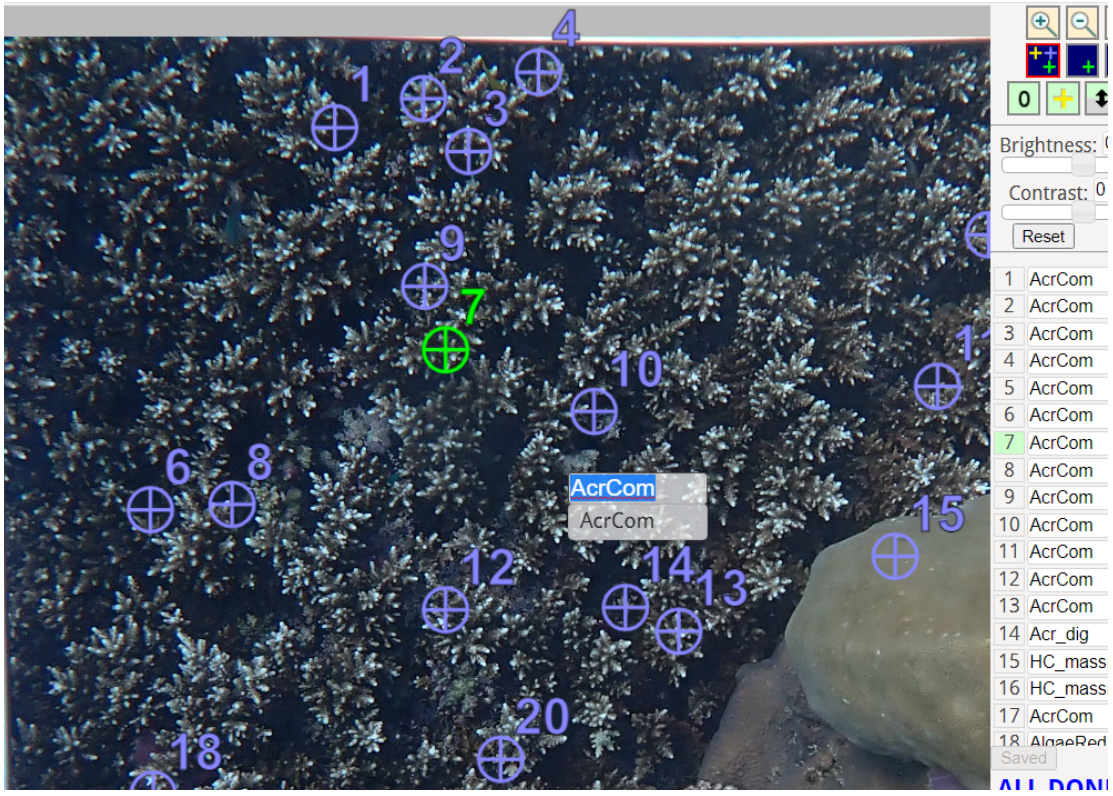


AcrSim (Acropora Simple) label used for long branching staghorn species or simple branching *Acropora*

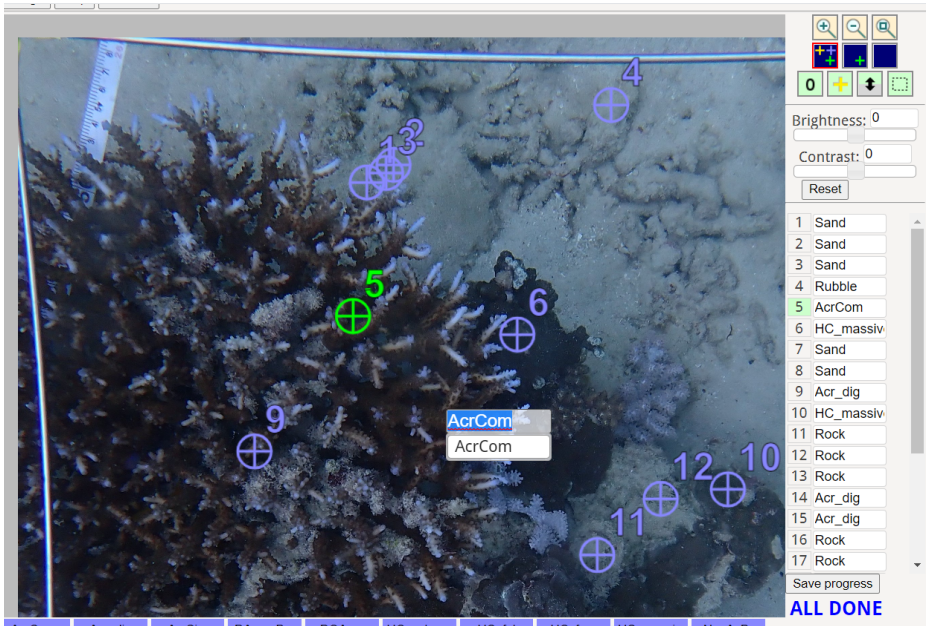


AcrCom (Acropora Compound) label used for all compound branching Acropora species or the bottlebrush corals.

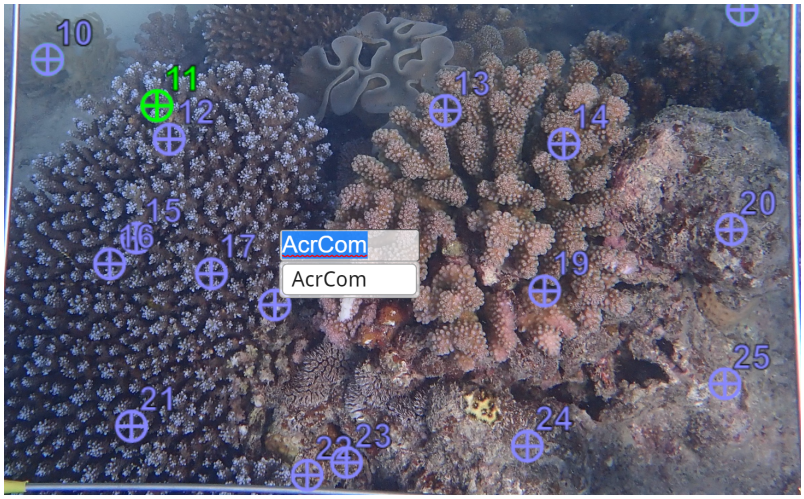


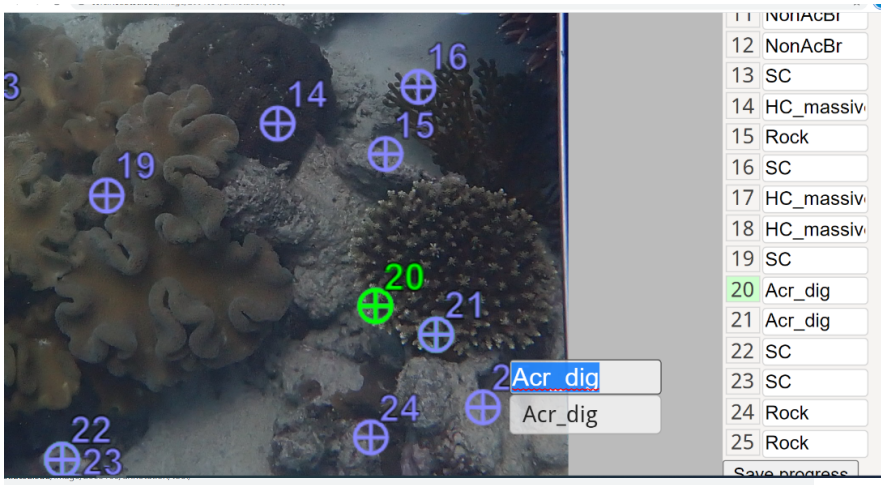


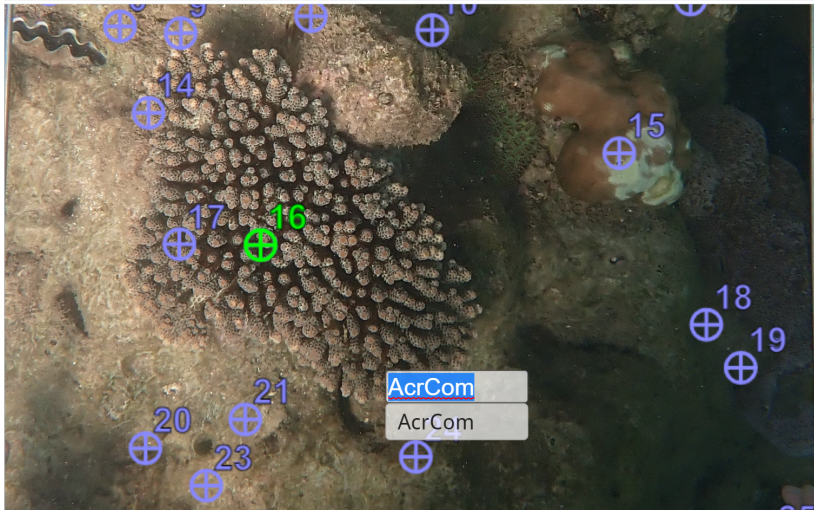
A. loripes to always be labelled as AcrCom.



AcrDig (Acropora Digitate) label used for all *Acropora* that isn't Staghorn (AcrSim), Bottlebrush (AcrCom) or Plating Acropora (PLATE). Examples of *Acropora* digitate corals that were commonly being labelled as *Acropora* compound:

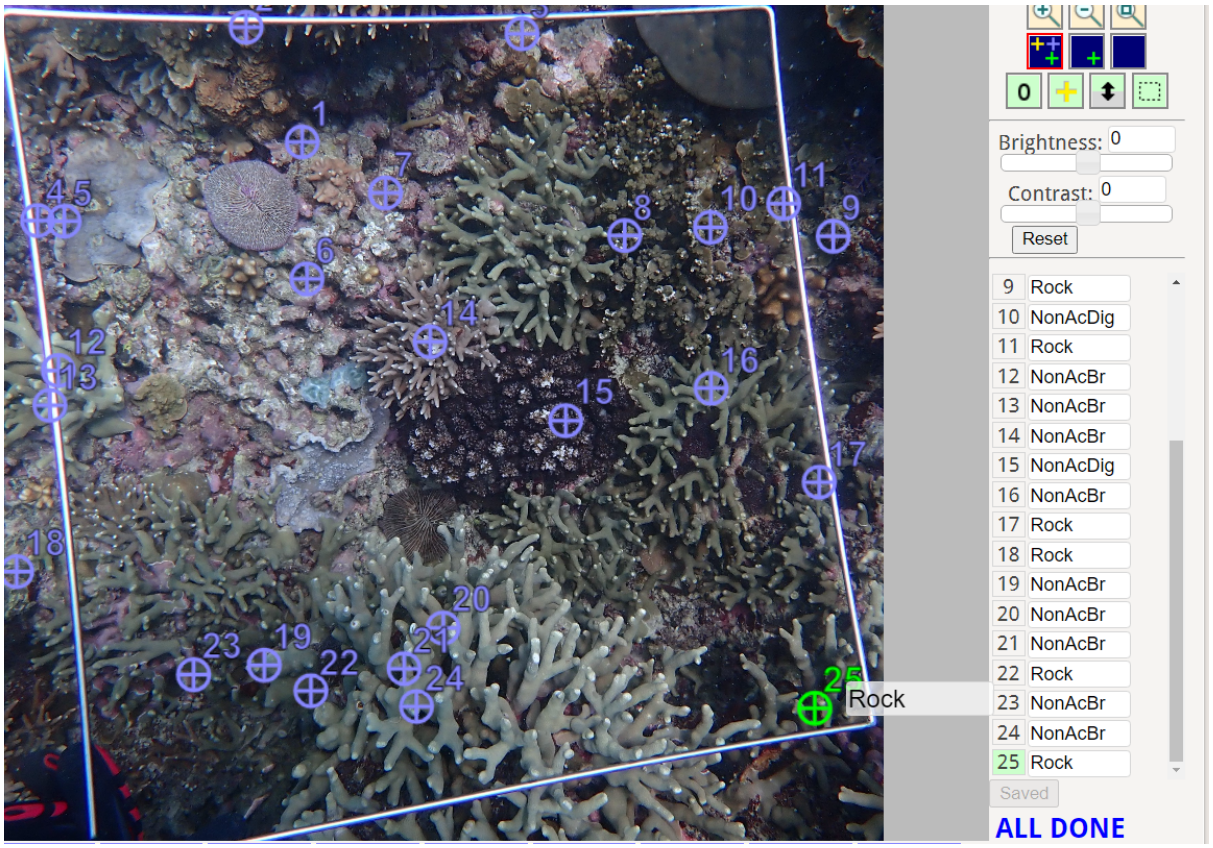




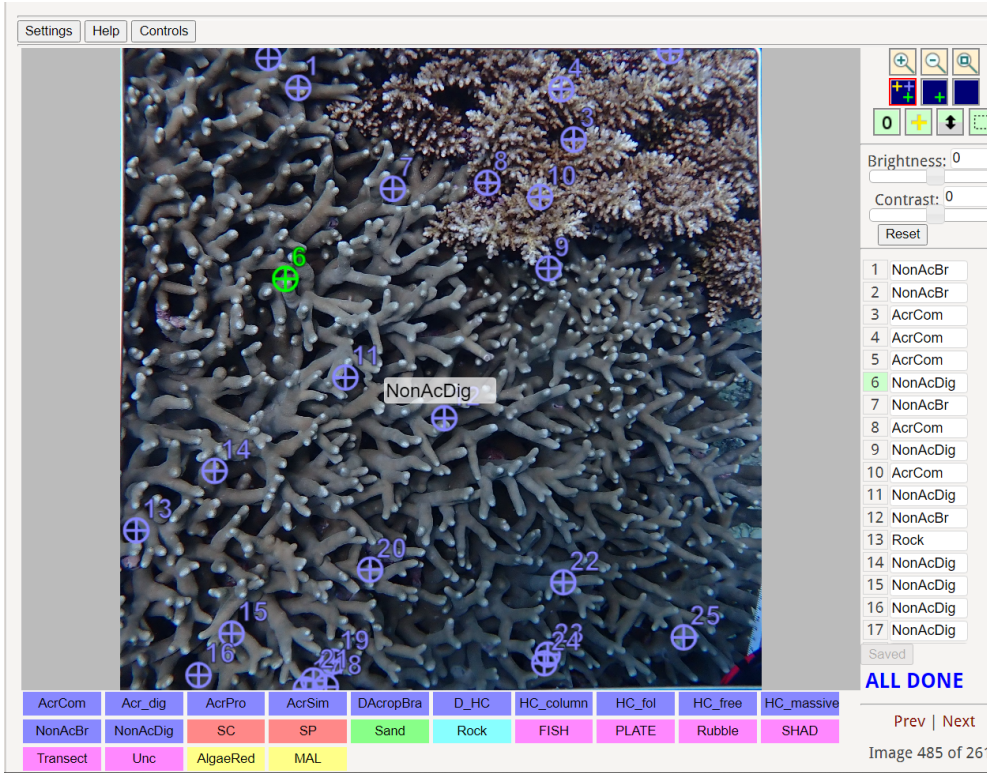


Coral colonies with no axial polyp

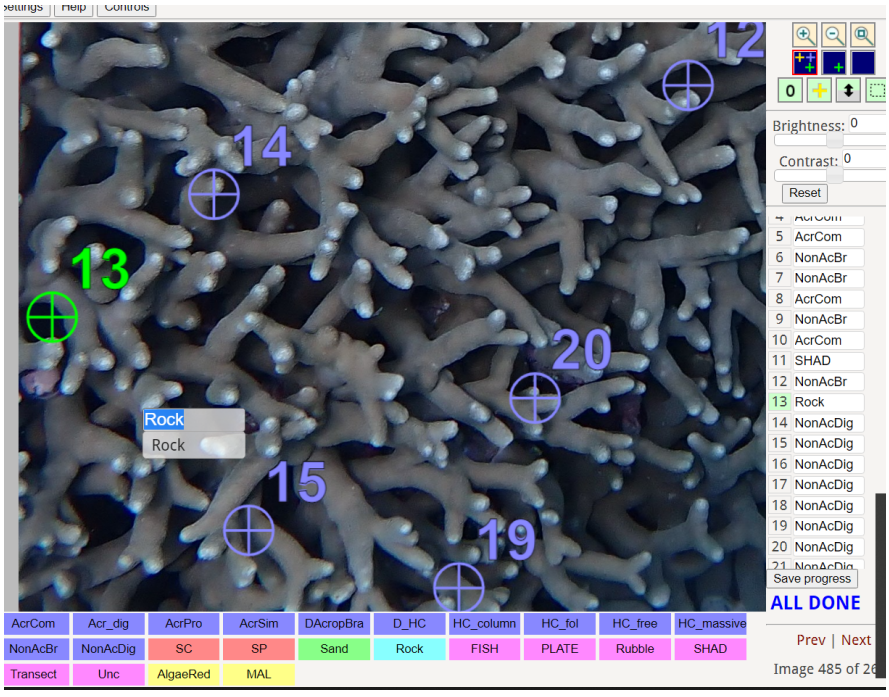
NonAcBr (Non Acropora Branching) labels branching corals that do not have an axial polyp or from the genus *Acropora* and such as many species from the genus *Porites* and *Seriatopora*.



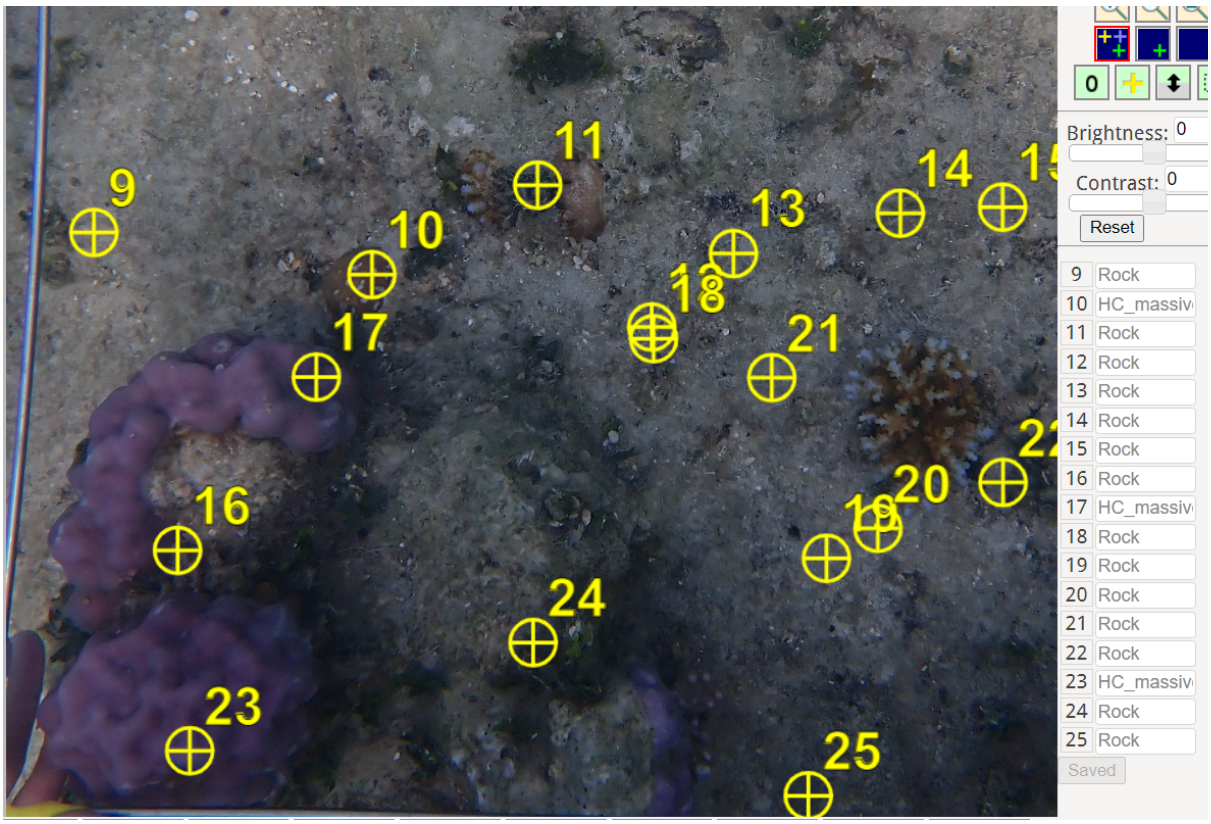
In the below example, *P. cylindrica* had been annotated as NonAcBr for the first two points then as NonAcDig for the rest, this is a big reason for having problems in the confusion matrix as the exact same texture and colour was being labelled as different things.



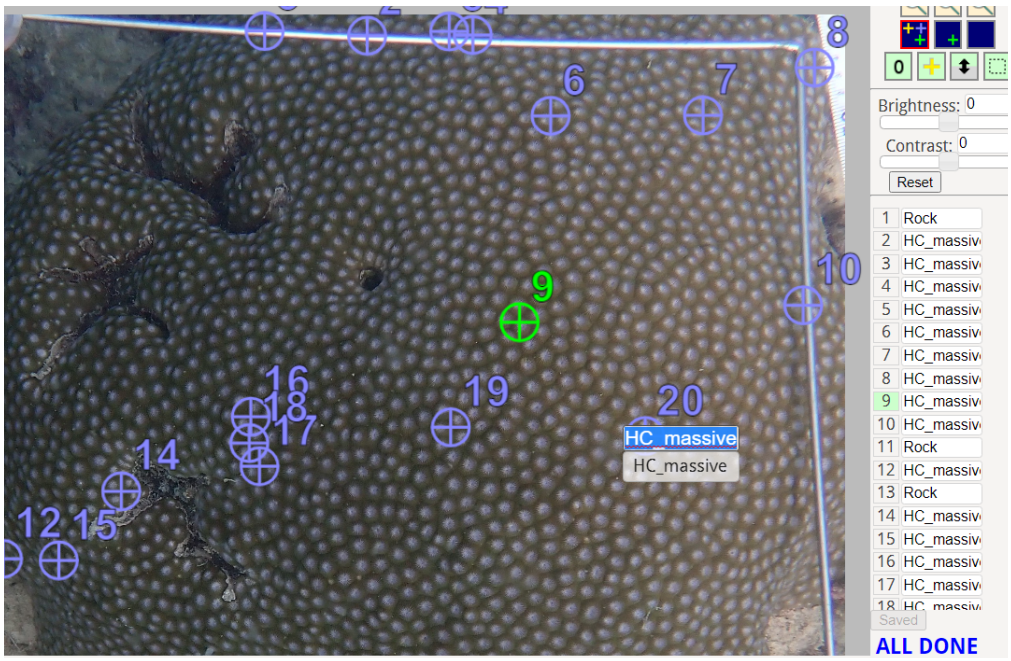
In the same transect, point 13 has been labelled rock when it is shadow.

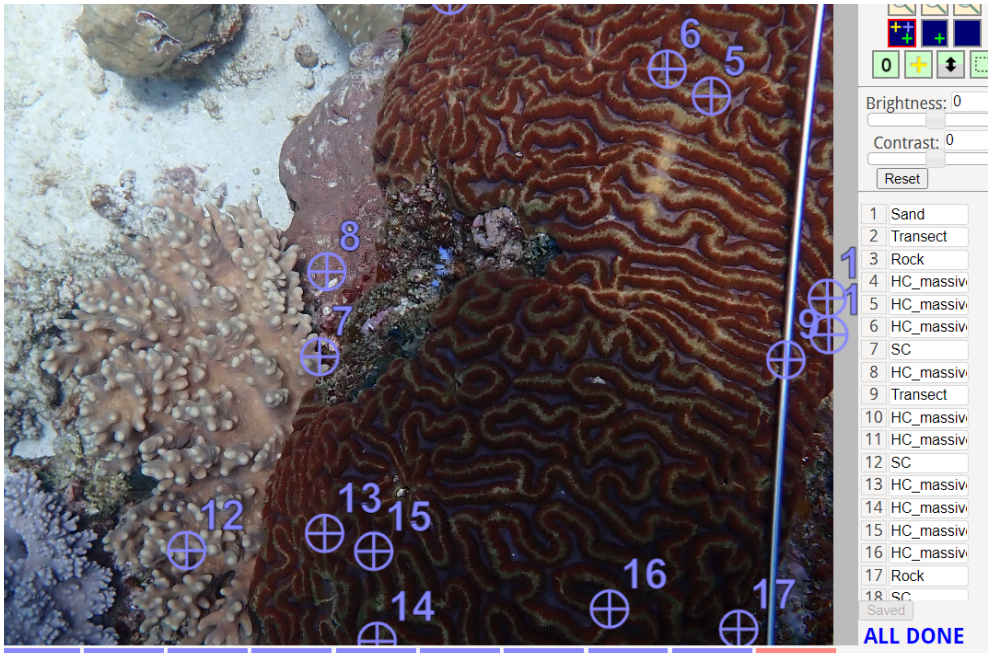


HC_massive (Hard Coral Massive) any massive hard coral. Predominantly *Porites*.



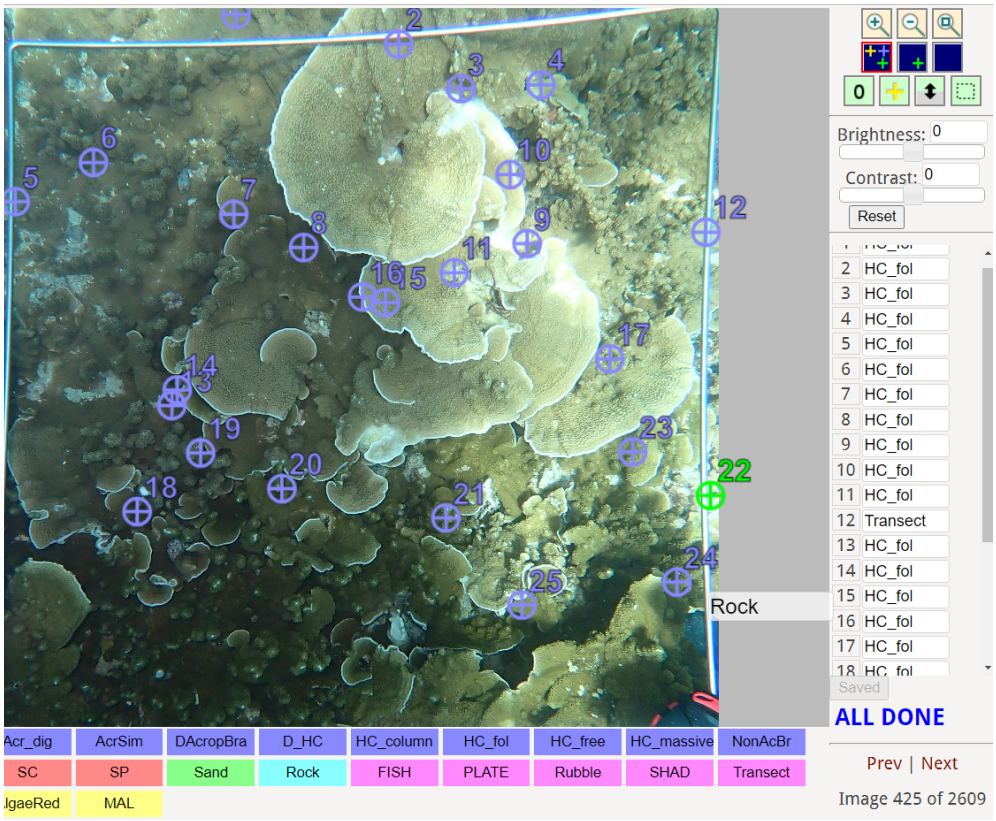
Any coral with a massive growth form such as many species from the families Mussidae and Faviidae are considered HC_massive.





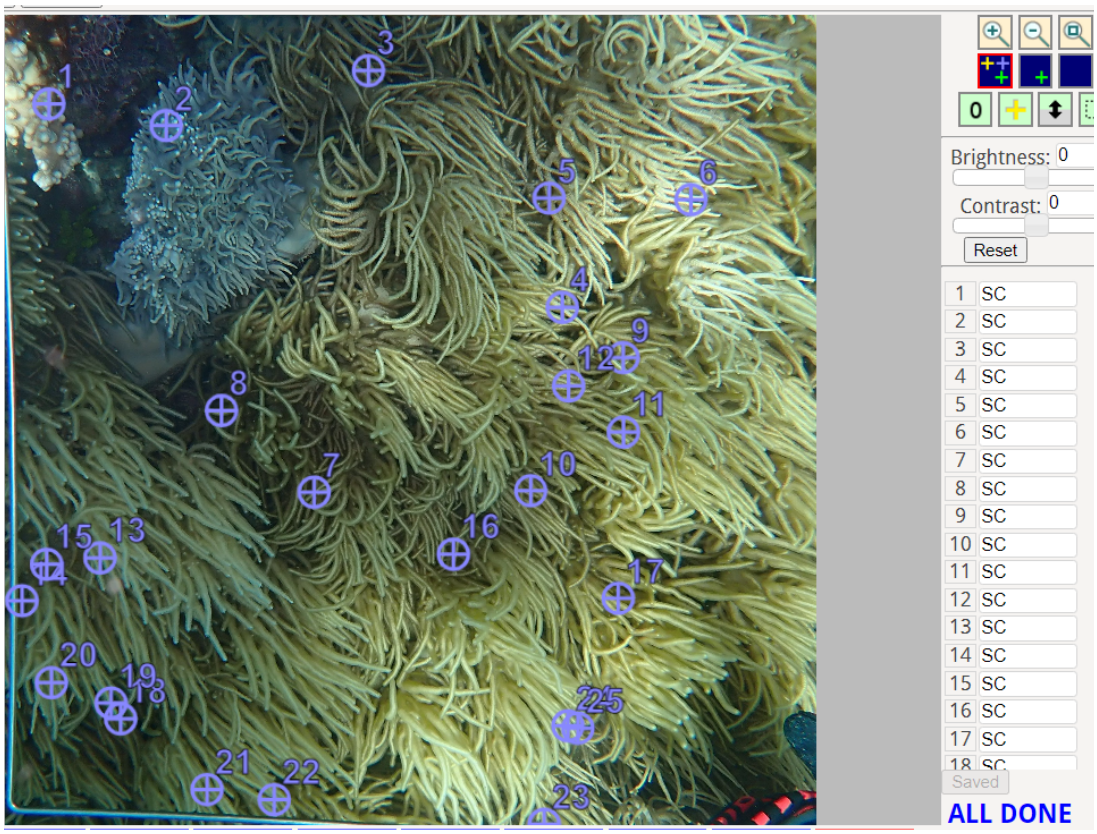
HC-free (Hard Coral Free Living) for any free living Fungiidae corals

HC_foliose (Hard Coral Foliose) is used for the whole colony such as many *Montipora* species that display foliose growth.

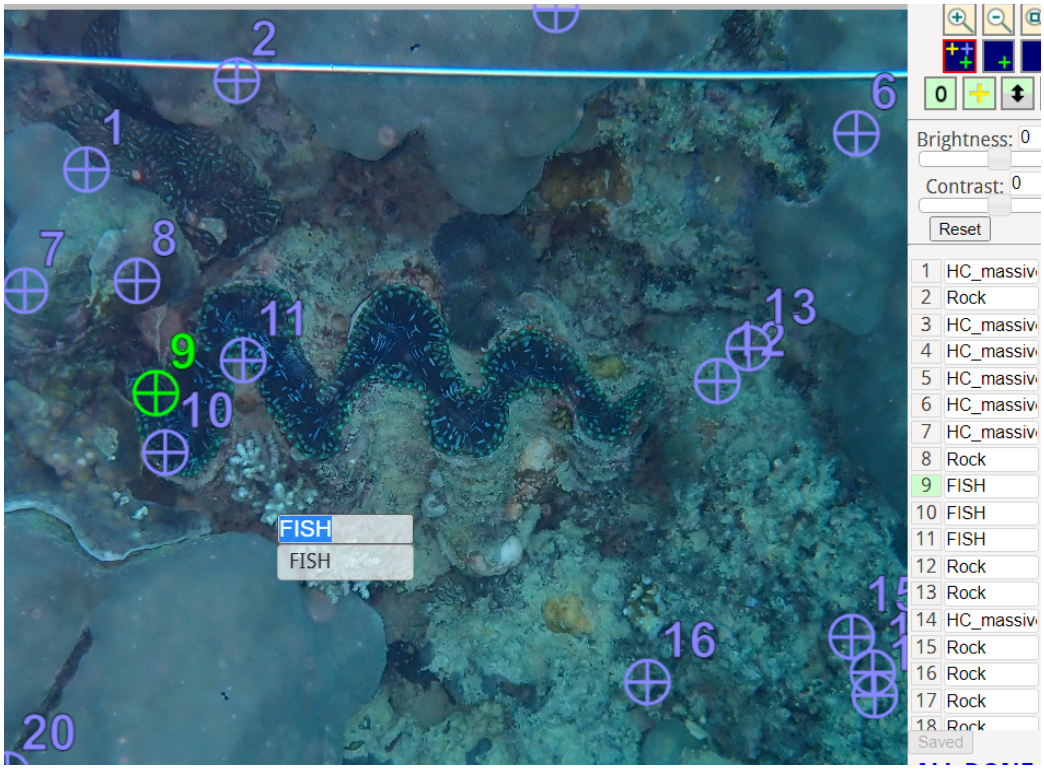


Other benthos

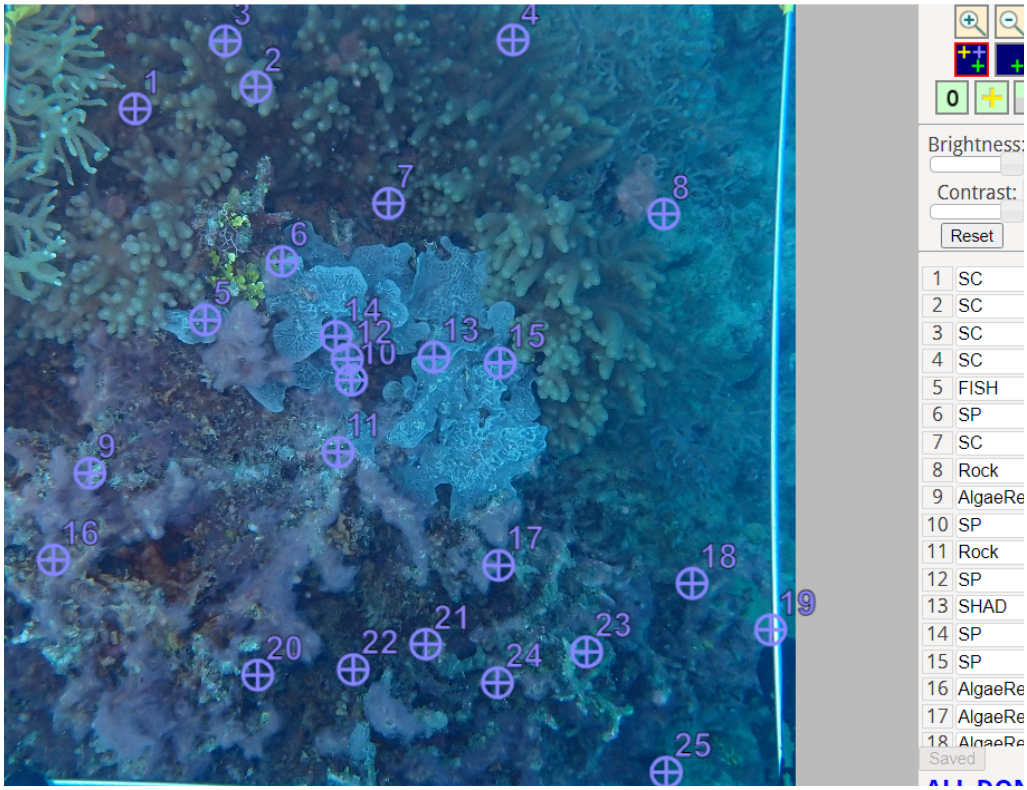
Soft Coral (SC) is for any species of soft coral. In our photos predominantly Sinularia and Sarcophyton



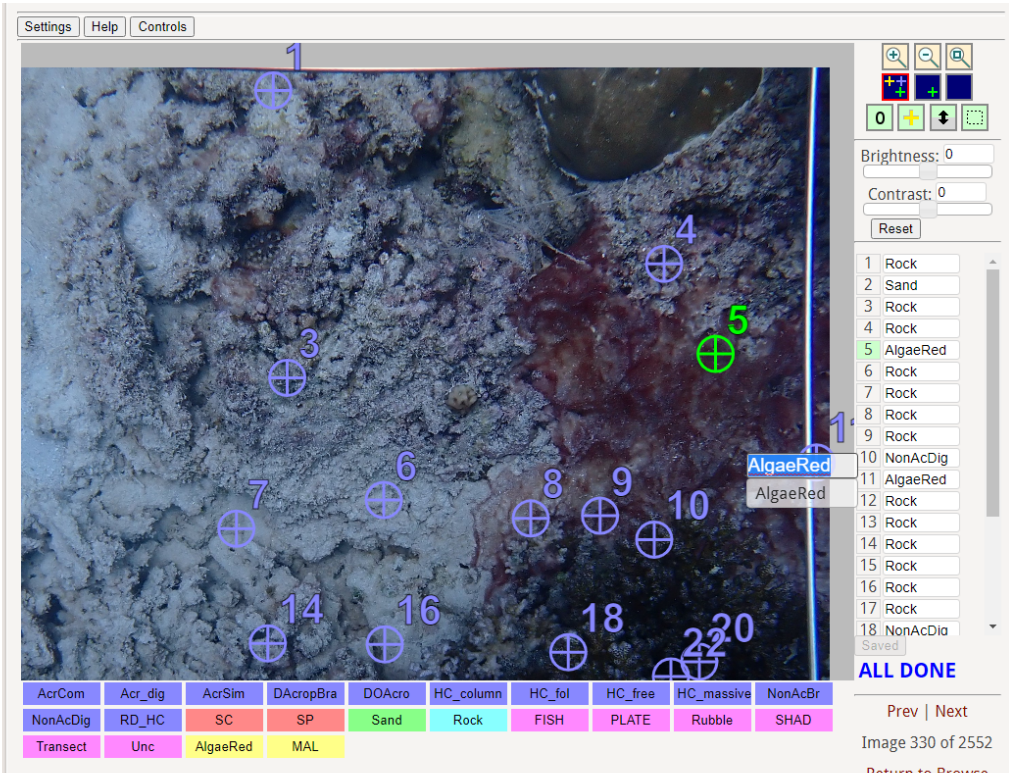
FISH is used for non-substrate organisms such as fish. For our photos this is predominantly clam tissue. Clam shell would come under rock.



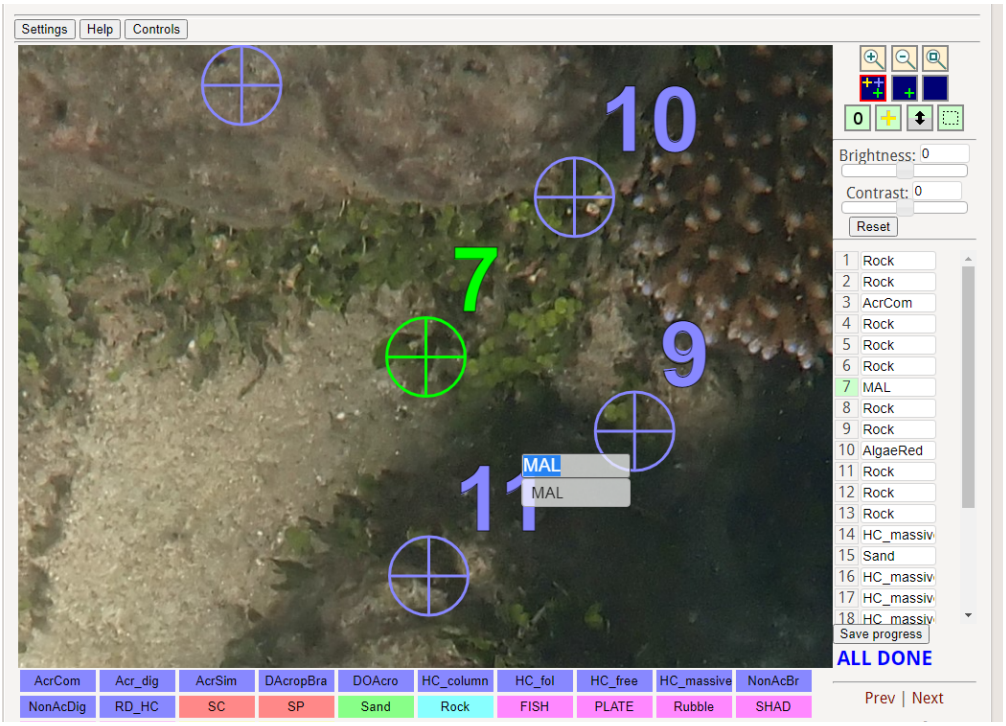
Sponge (SP), is used for benthic Sponges and ascidians.



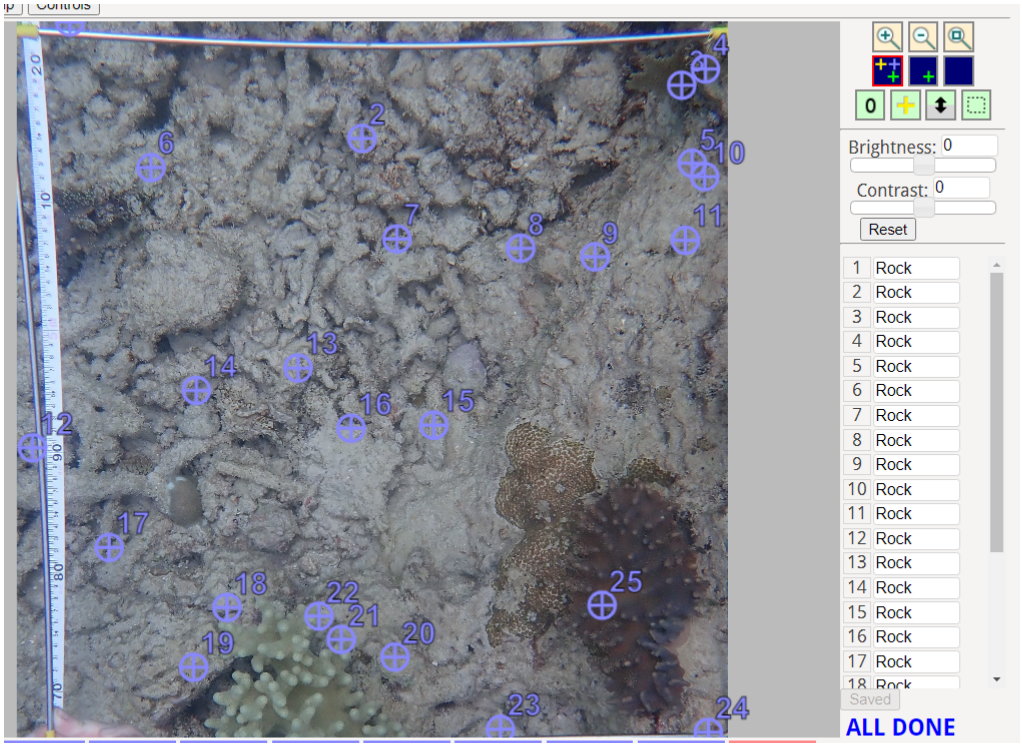
Algae Red, best to separate mainly separate slime algae and red filamentous algae from other macroalgae types. Which improved the to avoid confusing the classifierpreviously we were lumping slime algae with macroalgae and it was confusing the classifier.



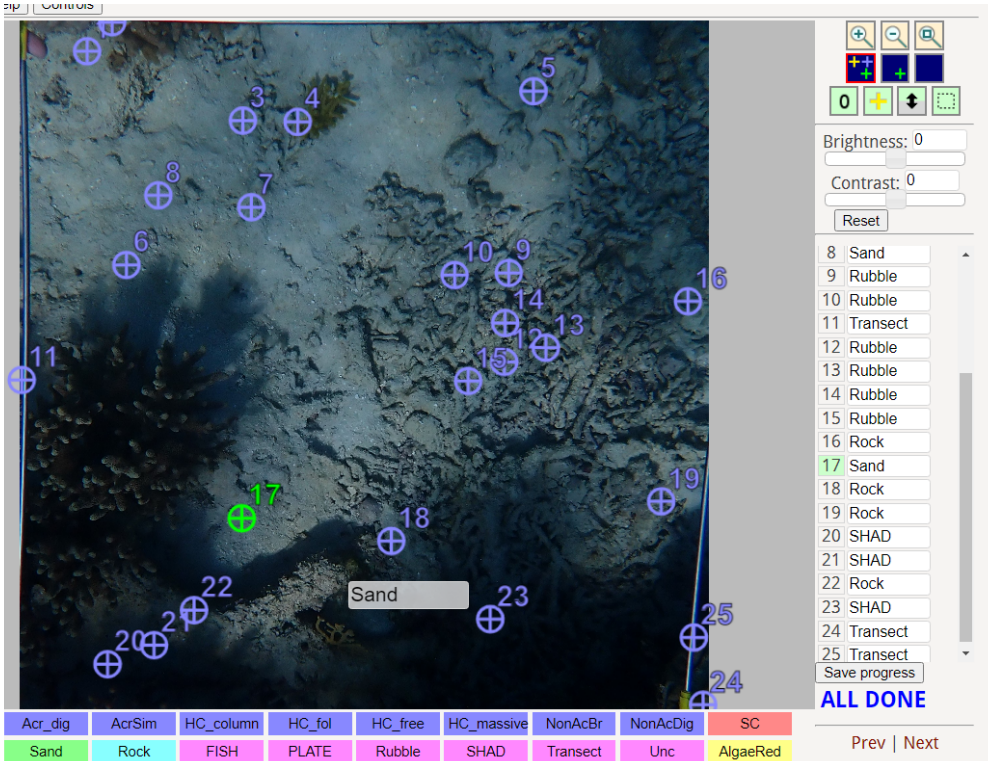
Mal (Macroalgae) for green Halimeda and turtle-grass etc



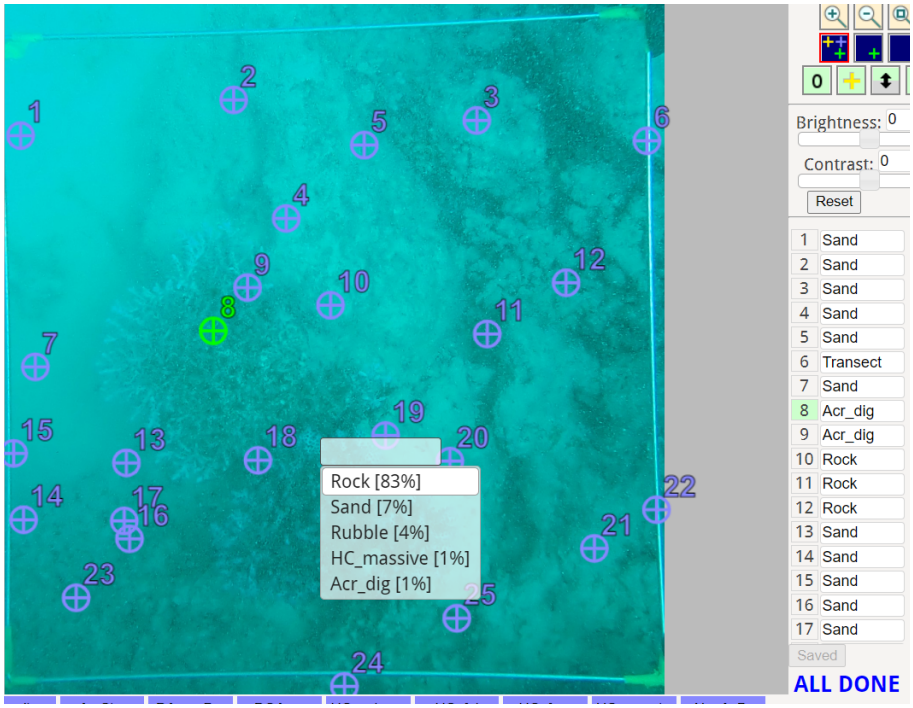
Rock is deemed to be any live coral rock that is consolidated to the point where coral recruitment and settlement could occur. This includes CCA. Many of the photos contain areas that may look like rubble at first glance, though on closer inspection you can see that it is consolidated and contains either cca or turfing algae. These areas are labelled as rock as they are available for settlement and coral growth.



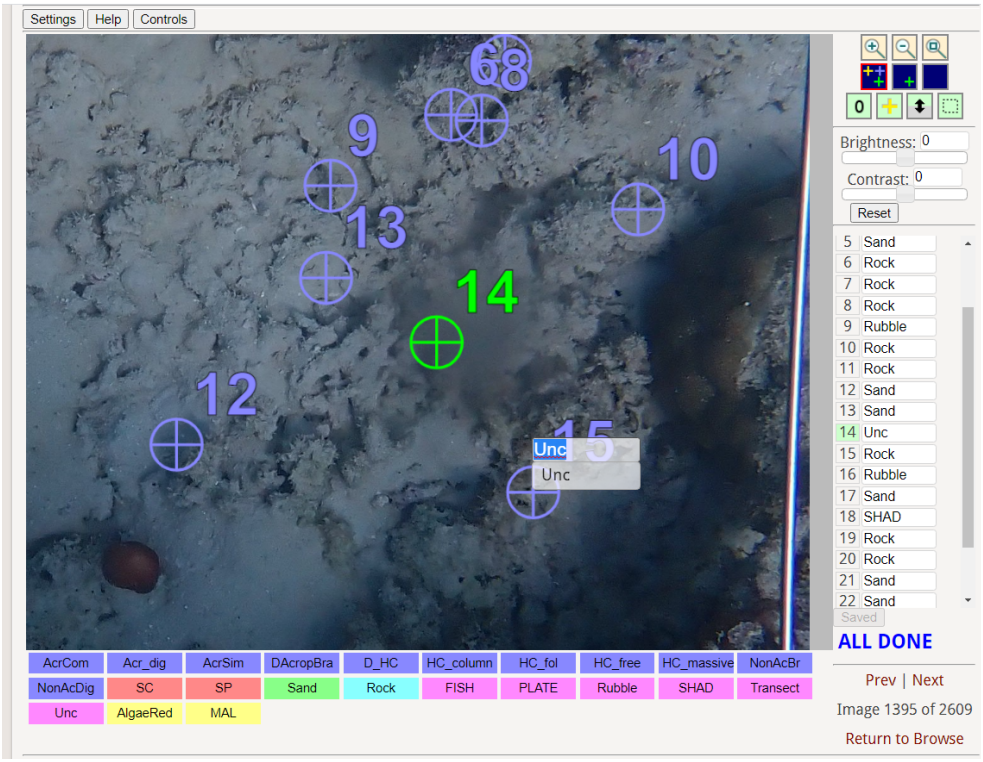
Rubble is any unconsolidated rock that is not available for coral settlement or growth. Example below:



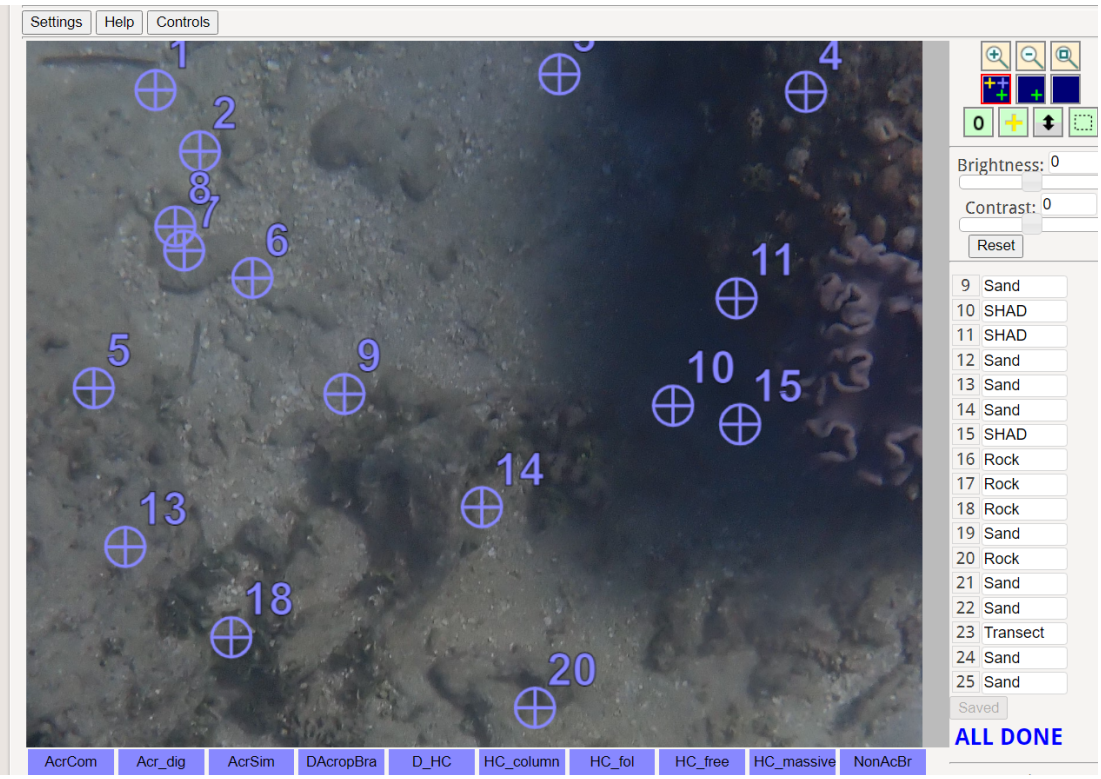
Photos that are this washed out and high off the bottom need to be deleted as the texture confuses the classifier. You can see it was 83% sure this *Acropora* was rock.



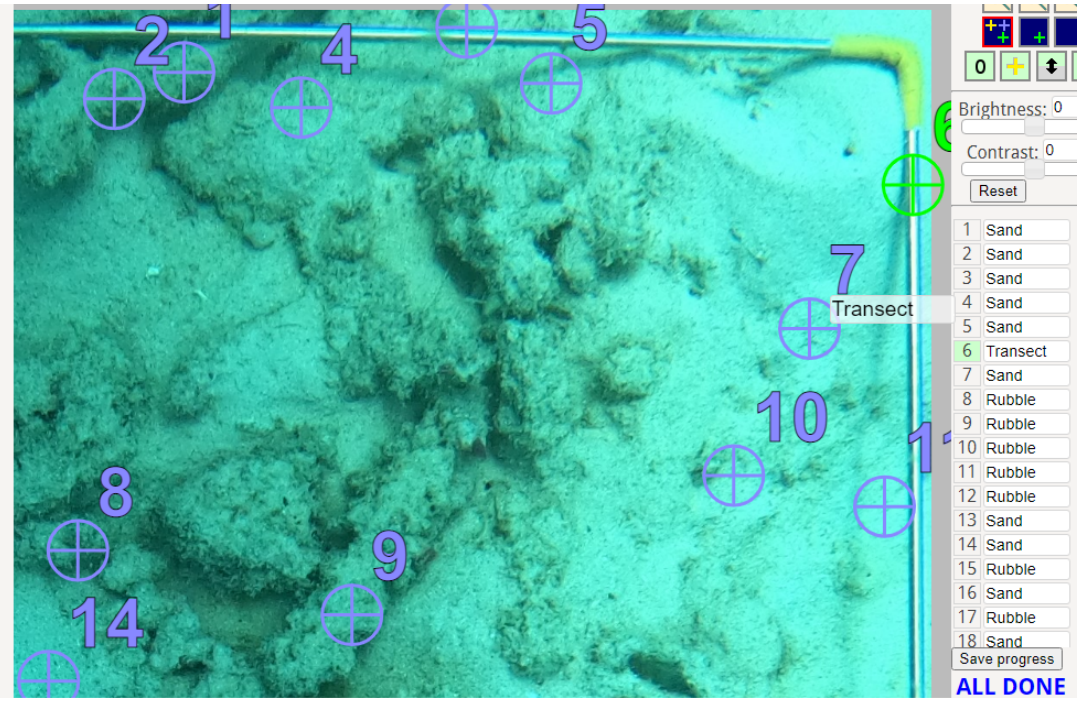
Unc (Unclear) used for unclear benthos such as when there are bubbles on the lens, or the benthos is blurry. This can also be used if you are personally unsure of what the benthos is. On CoralNet it is easy to search Unclear under the Patches tab and someone else can rectify the point.



Shadow to be used for points that are so dark that by zooming in you cannot see the texture of the benthos. In the below example, to the trained eye you would classify points 10, 11 and 15 as sand. But if we annotate them as sand we are teaching the classifier that dark areas are sand while in other transects the dark area could be live coral or rock. So, to get consistency in the classifier we need to mark all areas like this as SHAD.



Sand covering a rock to the point where under the crosshair the texture is only sand, it should be labelled as sand rather than rock. In the below example most of the crosshairs would be sand. This makes sense when considering our definition of rock being somewhere that a coral could potentially recruit as the area below would have very low settlement.



Coral predator surveys

To estimate densities of coral predators we suggest performing belt transects of a specific dimension. During Kul-bul we used belt transect dimensions of 30m x 6m. Divers lay the transect tape out in a random direction for 30m. Then SCUBA divers systematically worked either side of the transect tape at a width of 3m from transect tape. During the survey, coral predators such as crown-of-thorns starfish (CoTS) and Drupella snails are counted, measured and prey coral species noted. During our surveys CoTS were collected and Drupella were only counted (not collected) within size estimates of 0-3cm, 3-5cm and greater than 5cm. If any CoTS are found, they are to be carefully extracted and placed in an appropriate sealed container. CoTS have numerous venomous spines, and we emphasise caution and suggest minimal handling. Densities of CoTS and Drupella can be calculated easily from the known accumulative transect area and can be expressed as number of individuals per hectare.

Coral fragments of opportunity

Coral fragments of opportunity were considered greater than 10cm in length and no longer physically or biologically attached to the substrate. Fragment density was estimated by laying out a 30m transect and using a quadrat ($0.25m^2$). Place first quadrat a 0m on the left-hand side of the tape. Within the quadrat count and identify all suitable coral fragments. This is repeated every metre, alternating sides until 30 quadrats have been completed. Fragments that could be secured to a MARRS Reef Star were considered suitable and mainly comprised of corals from branching, bushy, digitate or plate morphologies.

Appendix B – Counting Spawn Method

Every spawn counts
Aims and objectives

You always hear people say, "Wow that was the best spawning!"
But how do we know it's a good spawning event?
So we firstly needed to....

Develop a method for counting coral spawn

1

The Every Spawn Counts project uses simple equipment that many scuba divers have access to. The current gold standard for counting spawn tends to interrupt the natural reproduction process where bundles from a single colony are captured. With this in mind, the project is designed to have the least effect on the natural spawning process. Many marine protected areas require permits for people to undergo research, this project eliminates the need to go through the lengthy process of applying for permits, as it can be completed by recreational divers.

Develop a framework for analysing data

2

We have all the footage so now we need to extract the data and analyse it. Using freely available software bundles are counted, this information can then answer questions like:
What species of coral was spawning at what time? On average how much spawn per minute does a certain species of coral spawn? Was this different to other reefs in the area? Was this different to previous years?
This information can then be used in the protection and management of your reefs and potentially other reefs around the world.

Develop and implement a program for citizen scientists

3

Mass spawning events can occur across great distances at the same time. Think about how big some reefs are, places like the Great Barrier Reef. This makes it incredibly difficult to get to all the reefs at once, this why its important to create a method that anyone diving on spawning night can be involved in. This increases the amount of data we can get significantly and allows the greater community to become involved.

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Instructions

A step by step guide

On your dive you will need…

- Underwater Camera
- Underwater torch
- Underwater booklet (supplied by project organiser)

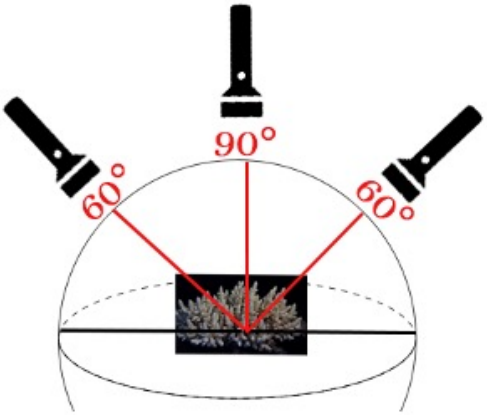
Ensure camera has correct time and date you can also choose to show the time and date on the recording (time stamp)

1

Locate a colony that is spawning, this sounds easy, but finding the right colony that will be easy to film can be a little tricky. Remember to always remain neutrally buoyant and please do not to touch the coral. Some species of coral can be sensitive to light, so you might find that as soon as you shine your torch on the colony it stops spawning, if you find one like this you could note is down and take a photo, but best to leave this colony alone and find another to film.

2

Using your torch on lowest light setting, position the torch above the colony, facing downwards. This may be difficult in some situations, try to stay between 90° and 60° as seen below.



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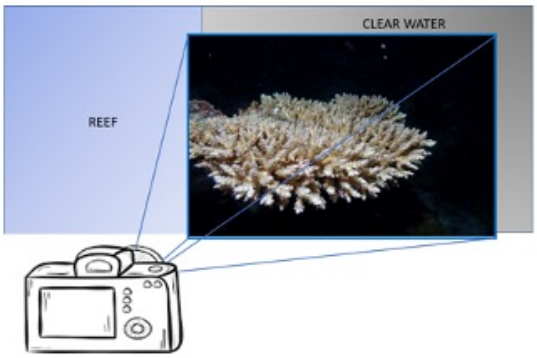
Instructions

A step by step guide

3 Using your camera record 1-2 mins of the coral spawning as shown in picture below, with dark mid water behind the colony. Its best not to keep the background as clear as possible avoiding shots with otherer colonies, marine life or live rock in the background. Try to frame as much of the colony in the shot as possible.



4 Complete data sheet as per the below example

When it comes to filling out the size information you will see a ruler on the bottom of each data sheet, this should help give you a rough estimate of the size, you are not expected to measure each colony precisely.

Date	Time	Colony #	Depth	Length	Width	Height
10/11	7:30pm	1	3.4m	15cm	20cm	10cm

You will need to fill this out one line for every recording, so if you stop a recording, reposition yourself and start recording again, just complete the time and colony number, you can leave the rest of the columns blank.

Optional - If camera allows, get a super close up photo of the polyps. These make great photo's for you as well to share with people, just like this one of an Acropora species, just moments before it releases those bundles.

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Tips and tricks for getting great footage

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1

You can smell it!

Since you will have a limited air supply, how do you know when to get in the water?
Well, like many scientists out there, you will wait for the smell.
Yes you can actually smell the spawn!
This is a real distinct pungent smell that is hard to describe, and can be akin to the smell of the reef at low tide, when parts of the reef flat are exposed.

2

Go for a practice dive and scout the reef

Perhaps there is an opportunity to go on a practice dive. Or a day dive to scout the area.
This is a good idea to do, just so you are super comfortable with your equipment and the process underwater.
If you dive the same reef, its good to note where colonies of the same type are, so if you cant get a good shot with a colony that is spawning you know where other colonies of the same type are and can move on quickly.

3

Learn your equipment

Every camera is a little different, but make sure you have your camera set to wide mode, so you can capture as much spawn as possible. You might have a macro or microscope mode of your camera, if so learn how to quickly change from one setting to another so you can capture a few pics for yourself of a single polyp releasing it bundle. Its also a good idea to keep your camera on auto focus, especially if your new to diving or have not used the camera on a regular basis. Its also a good idea to make sure you have all your equipment attached to you.

4

You can also work with your buddy

Although this programme is designed to be conducted by a single diver, if your buddy would like to get involved or your new to night diving, you can work together. Having two divers scouting for spawning colonies is always better than one. Also, one diver can control the camera and the other diver can control the torch. Just remember to come up with some hand signals for

Remember

Try to just capture the spawn bundles, if there is too much background we might not be able to use the footage.
This is also the case when you get lots of other animals feeding on the spawn like these marine worms. If this is happening simply move onto the next colony.

After your spawning trip

Download your photos and videos into one folder on your computer.

Label the folder
Yourname_Location

You and your GBR Biology representative should arrange how to supply the footage prior to your dive.

We can accept SD Cards, USB Devices or arrange cloud based upload and sharing options.

Please ensure you also return your completed booklet.

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Appendix C – Coral Recruits

Deploy settlement tiles on selected reef site in the days leading up to broadcast coral spawning event. In Kul-Bul we deployed 40 tiles per reef site, with 20 placed on the reef flat and 20 within the coral lagoon. Travertine (terrestrial limestone) tiles (10 x 10 x 2.5cm) with a 7mm hole drilled in the centre, were secured to the substrate via a 20 cm stainless spike. The spikes were 7mm in diameter and driven 10cm into the hard live coral rock with a handheld hammer. The tiles were positioned ~5cm above the substrate.

Approximately 6-8 weeks after the broadcast spawning event, the tiles were retrieved and placed in a 20% bleach solution. The bleach solution dissolved organic material and left coral skeletons reasonably intact. When tiles were dry, the top, bottom and sides of the tile can be examined for coral recruits. With some training coral recruits can be identified to genus level and recorded (Fig. 1). Information at this level assists to determine the proportion of brooder versus broadcast spawning recruits.

Fig. 1. Example of skeletal difference in coral recruits to aid in identification. For further information on identification and assistance, please contact Eric Fisher at GBR Biology.

Appendix D – Fine Scale Hydrodynamic Monitoring

Several novel instruments are readily available to measure temperature, light and current flow. Several manufactures such as HOBO Dataloggers produce a range of waterproof instruments to measure water temperature and light. In the KulBul project we used Marotte HS (High Sampling Rate) drag-tilt current meters to measure current flow and direction over time. Like temp/light loggers, the current meters are quite affordable and assessable. This easily allows several instruments to be deployed at a reef site and used to create a holistic picture of local scale hydrodynamics.

Appendix E – Safeguard Traditional Owner Ecological Knowledge.

Throughout the development of the Kulbul project, it has been paramount to safeguard the Yirrganydji Indigenous Ecological Knowledge (IEK). To ensure this, members of the Yirrganydji community have been involved in the development and implementation of the project to guide and protect the use of their IEK.

We have outlined steps below as a draft process to generate a framework that was agreed between all parties. A key part of establishing and maintaining the process was the constant consultation with the Yirrganydji community.

Establish project steering committee.

Intention to discuss project intentions, goals and protocols that respects and safeguards IEK. The following recommendations included,

- Create a Memorandum of Understanding (MOU)
- Elders and other members of Yirrganydji community to visit Sea Country and witness project activities and engagement.
- Deliver a Cultural awareness field day to create an atmosphere of recognition, respect and understanding towards the connection between Yirrganydji and Country
- Include Yirrganydji artwork and creative ideas in the development of Kulbul logo and website.
- Hold discussions with various elders of the Yirrganydji community to discuss IEK and Yirrganydji Sea Country and how to incorporate into Kulbul project.

Actions Delivered

Memorandum of Understanding (MOU):

- Created between Dawul Wuru Aboriginal Corporation, GBR Biology and Reef Restoration Foundation.

Sea Country visitation:

- By Yirrganydji elder and Land & Sea Country rangers to observe the in-water research monitoring programme and customer and staff engagement with Tourism operator Dreamtime Dive & Snorkel.

Cultural awareness field day:

- Yirrganydji Land & Sea rangers from the Dawul Wuru Aboriginal Corporation giving project representatives, partners, and relevant community members a tour of their country and detailing the cultural significance and connection to Country.

Respectful Cultural presentation with Yirrganydji Community approval that incorporate:

- Acknowledgement
- Language
- Artifacts with right terminology and cultural significance.
- History, LORE and stories.
- Quality assurance and best practice
    - Having Yirrganydji working on the project, particularly Tarquin Singleton, has taught respect and acknowledgement of the Yirrganydji culture. This has been accomplished by Tarquin conducting acknowledgments, teaching staff and customers Yirrganydji language and giving guidance on cultural presentations.
    - Regular meetings between all Project Partners to improve and encourage best practise to acknowledge, recognise and respect Yirrganydji culture and IEK.

Communications involvement:

- Yirrganydji Community involved at the beginning of the project in website development, logo design, branding and communication delivery strategies.

IEK engagement meetings:

- View TUMRA
- Cultural significance of selected reefs such as, hunting, ceremony or sacred.
- Historic and current Reef Management practices.
- Discuss Seasonal calendar and Land Seasonal indicators link to Reef patterns of growth, feeding, migration and aggregation of animals.
- Connectivity patterns between Reefs and Land.

Kul-Bul
SPIRIT OF SEA COUNTRY

This Calendar illustrates the connections between land and sea. The plants are rough indicators for seasonal changes throughout the year and lines up with marine life. Due to the changing climate these plants may fruit and flower early or late and may indicate the presence of certain marine species.

The two main seasons in the Cairns and Port Douglas regions are **Kurrabana** (gu-ra-ba-na) meaning Wet season and **Kurraminya** (gu-ra-min-ya) meaning Dry season.

Then there are the sub-seasons with fruiting and flowering plant that may indicate the seasonal changes.

Jawarranyji (ja-wa-ran-jee) - *Storm bulid up*

Leichhardt Tree
Nauclea orientalis
Flower

Grey Mangrove
Avicennia marina
Fruit

Blue Gum
Eucalyptus tereticornis
Flower

Yiwanyji (yee-wan-jee) - *Windy time*

Weeping Bottlebrush Tree
Melaleuca viminalis
Flower

Native Peanut Tree
Sterculia quadrifida
Fruit

Native Black Bean
Castanospermum australe
Flower

Kabanji (ga-ban-jee) - *Rainy time*

Red Coondoo
Mimusops elengi
Fruit

Broad-leaved Paperbark
Melaleuca viridiflora
Flower

Eastern Gondola Bush
Tabernaemontana orientalis
Fruit

Wumbulji (wum-bul-jee) - *Hot time*

Pongamia
Millettia pinnata
Flower

Cocky Apple
Planchonia careya
Flower

Flame Tree
Brachychiton acerifolius
Flower

Jinjimji (jin-jim-jee) - *Cool time*

Yellow Wattle
Acacia flavescens
Flower

Coastal Wattle
Acacia oraria
Flower

Northern Wattle
Acacia crassicarpa
Flower

Silver-leaved Wattle
Acacia holosericea
Flower

Native Kapok Tree
Cochlospermum gillivraei
Flower

Marine Stingers

Crocodile active

Manta Ray Migration

Turtle Breeding Season

Turtle Nesting

Turtle Hatchlings

Whale Migration

Coral Spawning

Reef Fish Spawning

Kul-Bul Team

YIRRGANYDJI LAND and SEA RANGERS

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REEF RESTORATION FOUNDATION
CORAL NURSERIES GREAT BARRIER REEF

Funded by Great Barrier Reef Foundation and Reef Trust


KURRAMINYA
KURRABANA
JAWARRANYJI
KABANJI
JINJIMJI
YIMANYJI
WUMBULJI
KuL-BuL
SPIRIT OF SEA COUNTRY