marineeducation.com.au

Marine Education

Student Experiment

Name:

Date:

Year 12 Mandatory Practical

Examine the concept of connectivity within or between habitats by investigating the impact of water quality on reef health

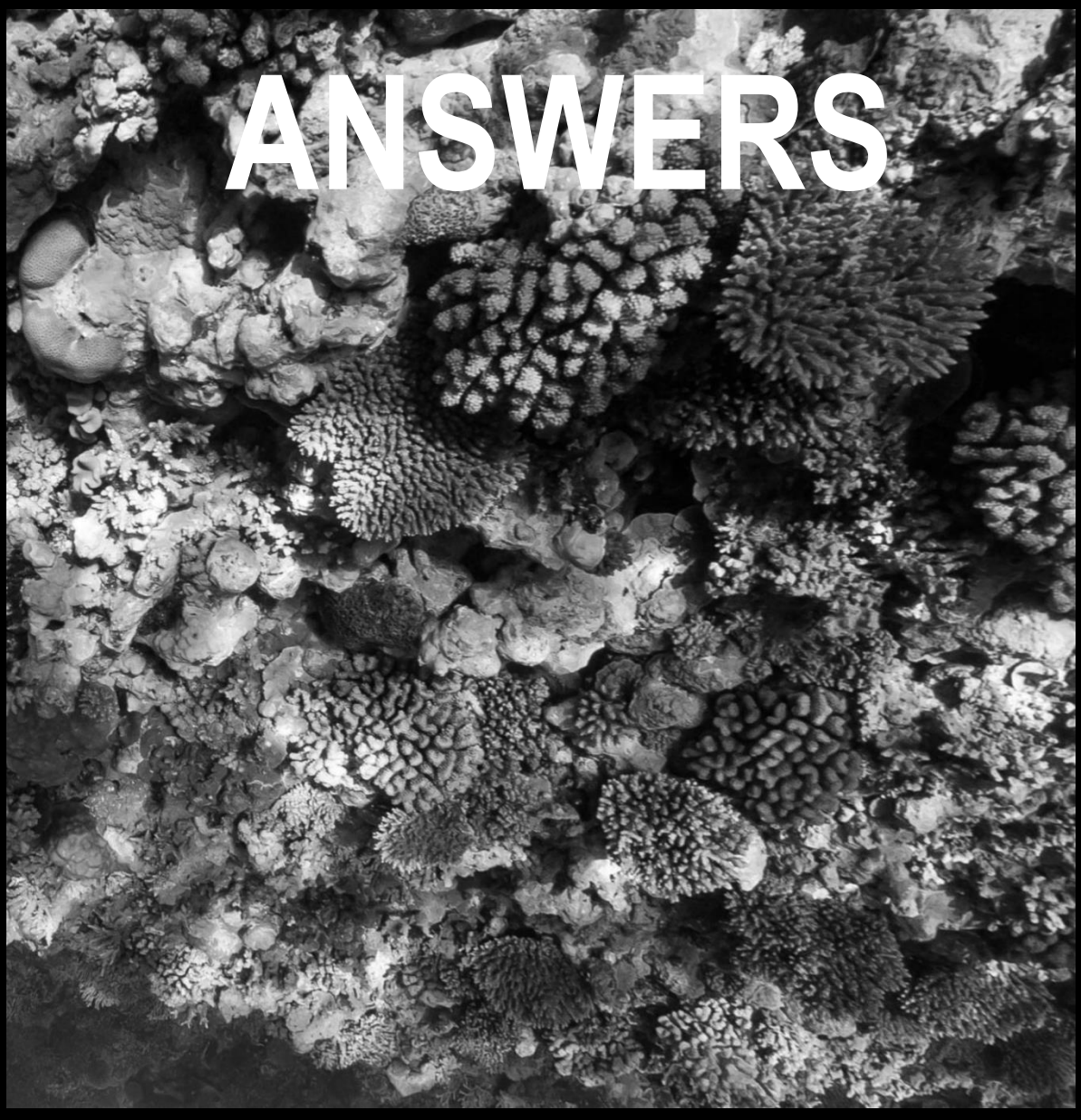


Image (of Osprey Reef) sourced from the XL Catlin Global Reef Record. © Underwater Earth / XL Catlin Seaview Survey

Gail Riches

Publisher
Gail Riches
Marine Education
ABN: 48765406873
PO Box 394
Bli Bli Qld 4560
Email: info@marineeducation.com.au
www.marineeducation.com.au

Edited by Maria Bavins

Course Overview and Learning Objectives derived from Marine Science 2019 v1.2 General Senior Syllabus[1]

ISBN: 13: 978-0-6484089-3-2

[1] Queensland Curriculum and Assessment Authority (2018). *Marine Science 2019 v1.2: General Senior Syllabus. QCAA*. Accessed 20th July 2021 from: https://www.qcaa.qld.edu.au/senior/senior-subjects/sciences/marine-science/syllabus

Interested persons are invited to contact the author for information or to indicate errors and omissions.

Making OBSERVATIONS

Name:

Date:

What's in the Water?

For this practical, we want to investigate the impact of water quality on reef health, whilst examining connectivity. Thus, you get to visit the reef! Even if it's only a virtual visit, you still get to see it! Let's begin by looking at reefs from all around the world (see activity below). Whilst you are looking, find a reef that you would call 'unhealthy'. Ask yourself, why is it unhealthy? Do you think water quality has anything to do with it? Alas, corals do live in water! And, how does that water even get to that reef? Connectivity right?!

Activity: View quadrat photographs from the following websites (tick when done).

- ❑ **XL Catlin Global Reef Record** www.globalreefrecord.org 'Enter' and then click on 'Data'
- ❑ **Reef Life Survey** www.reeflifesurvey.com Access 'Survey Data'
- ❑ **Classroom on the Reef** www.jcu.edu.au/classroom-on-the-reef Curriculum → Coral identification practical
- ❑ **MarineEducation.com.au** Data tab

For example, pictured below are quadrats from Lady Elliot Island (1) and Belize (2). They were captured as screenshots from the XL Catlin Seaview Survey Virtual Tour with the camera pointing down.

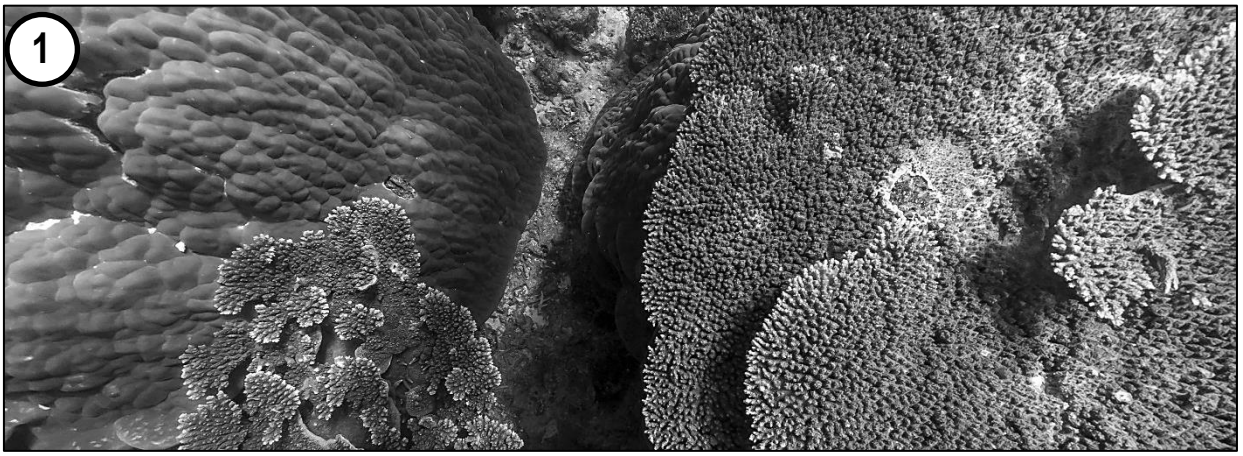


Figure 1: Image (of Lady Elliot Island) sourced from the XL Catlin Global Reef Record. © Underwater Earth / XL Catlin Seaview Survey

Figure 2: Image (of Belize Reef) sourced from the XL Catlin Global Reef Record. © Underwater Earth / XL Catlin Seaview Survey

Q. Which reef looks healthier? Ans. 1. Lady Elliot Island. Discuss why? Any bias? (i.e. one photo). How did they measure *health*?

GATHERING INFORMATION

Name:

Date:

☺ or ☹ Help or Hinder?

Connectivity can be a 'double-edged sword'. It can both help and hinder coral reefs.
- It can *help* reefs by delivering water carrying coral larvae and other hitch-hikers for replenishment.
- But, it can also *hinder* reefs by delivering water carrying unwanted COTS larvae[1] and pollutants.

Q. How might connectivity (1) help a reef and (2) hinder a reef? Ans.

(1) it helps by delivering water carrying coral larvae for reef replenishment.
(2) it hinders by delivering water carrying unwanted COTS larvae and pollutants

Eddying Around

Pictured right is a meso-scale eddy dubbed the 'Capricorn Eddy'. When water from the East Australian Current (EAC) flows past a huge 'wedge' in the continental shelf, the water 'swirls' around clockwise in a big circle. Inside the cyclonic feature is an **upwelling**, where **cool**, **nutrient-rich** waters rise up from the deep and spill onto the Capricorn-Bunker reefs[2]. One of those reefs is Lady Elliot Island (LEI), where many mantas rays visit.

Q. Is the Capricorn Eddy helping or hindering reefs of the Capricorn Bunker Group? Ans.

Could be both. Helping (if water is cold enough to mitigate bleaching); or, Hindering (corals don't like nutrient-rich water).

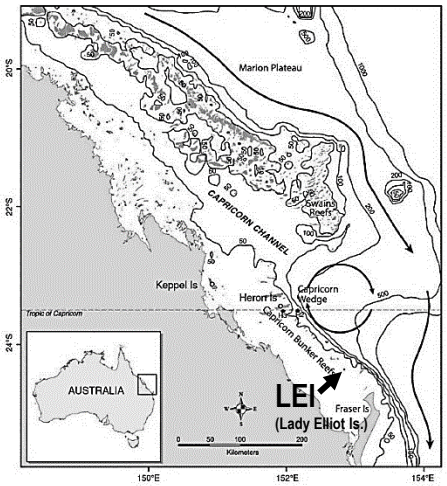


Figure 1: Schematic map of southern GBR. Solid dark arrows represent the southward flow of the EAC. Dark circular arrows show the location of the Capricorn Eddy with an indentation of 200-m isobath, referred to as the Capricorn Wedge[2].

Marvellous Mangroves: coastal kidneys and natural nurseries

Reefs are better off when close to mangroves. Mangrove forests filter the water, stabilise sediments (with their roots), reduce coastal erosion and siltation, and trap pollutants. Mangroves also act as natural nurseries for important reef fish species, such as herbivores[3]. How awesome are mangroves!
In a study by Olds *et al.,* (2011)[4] there were significantly more fish at protected coral reefs and mangroves that were close together (by <250m) as opposed to protected coral reefs and mangroves that were far apart (by >500m).

Q. How does connectivity between reefs and mangroves help the reef? Ans.

They filter the water, stabilise sediments (with their roots), reduce coastal erosion and siltation, and trap pollutants. Mangroves also act as nurseries for important reef fish species, such as herbivores.

[1] Hock, K., Wolff, N.H., Ortiz, J.C., Condie, S.A., Anthony, K.R.N., Blackwell, P.G. and Mumby, P.J. (2017). Connectivity and systemic resilience of the Great Barrier Reef. *PLoS Biol 15(11): DOI: 10.1371/journal.pbio.2003355*
[2] Weeks S.J., Bakun, A., Steinberg, C.R., Brinkman, R. and Hoegh-Guldberg, O. (2010). The Capricorn Eddy: a prominent driver of the ecology and future of the southern Great Barrier Reef. *Coral Reefs. 29 (4): 975-985. DOI: 10.1007/s00338-010-0644-z.* Adapted with permission from Professor Ove Hoegh-Gulberg. Director, Global Change Institute. Coral Reef Ecosystems Lab UQ.
[3] Spalding M., McIvor, A., Tonneijck, F., Tol, S. and Eijk, P.V. (2014). *Mangroves for coastal defence: Guidelines for coastal managers and policy makers.* Published by Wetlands International and The Nature Conservancy. 42 p. Accessed 09.04.2019 from: https://www.nature.org/media/oceansandcoasts/mangroves-for-coastal-defence.pdf
[4] Olds, A. D., Connolly, R. M., Pitt, K. A. and Maxwell, P. S. (2011). Habitat connectivity improves reserve performance. *Conservation Letters 5 (1). DOI: 10.1111/j.1755-263X.2011.00204.x*

RESEARCH QUESTIONS
Dependent and Independent Variable

Name:

Date:

Dependent and Independent Variable

Both the Dependent variable and Independent variable must feature in the research question. For example,

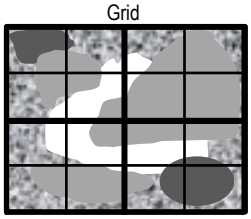
Q1. Is there a difference in _____ (Dependent variable) **between** _____ **and** _____ (Independent variable (e.g. two groups to compare)) **?**

Q2. Is there a linear relationship between _____ (Dependent variable) **and** _____ (Independent variable) **?**

Dependent Variable – Reef Health

How do we measure reef health? There are many ways. A common way is to estimate the **percentage** of **hard coral cover** using **quadrats,** either with the help of a grid (below left) OR datum points (below right)[1].

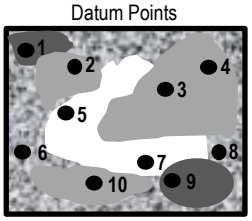
Grid



% Hard Coral = 40% (7.2 squares)

OR

Datum Points



% Hard Coral = 40% (2,3,4,10)

Coral Point Count with Excel Extension is a popular data analysis program that makes adding datum points to your quadrat photographs very easy. You can make the datum points as dots, crosses or even triangles, of any size. You can choose how many datum points to use, and if you want them randomly or evenly spaced[1].

Hard Coral **Soft Coral** **Coral Rubble** **Sand** **Rock** **Silt/Clay** **Nutrient Indicator Algae** **Other**

You could also use **CoralWatch** data[2] (in combination with % coral cover) to measure reef health!!

Independent Variable – Water Quality

How do we measure water quality whilst incorporating the concept of connectivity? One way is to create a set of questions that, when answered, allocate each reef a score for water quality. Whereby every '*yes*' answer is worth 1 point. The questions must be about how connectivity either helps or hinders a reef. Below is an example. Of course, you can create your own set of criteria/questions and scores.

QUESTIONS (Yes=1 No=0) (*Note*: 1 nautical mile equals one minute of latitude or longitude)

1. **Is the reef within 1 nautical mile of a mangrove forest or seagrass meadow?**
2. **Is the reef within 2 nautical miles of the continental shelf?**
3. **Is the reef within 30 nautical miles of the continental shelf?**
4. **Is the reef >30 nautical miles away from a major river carrying urban runoff?**
5. **Is the reef >30 nautical miles away from a city with a population > 50,000?**
6. **Is the reef within a Marine Protected Area?**
7. **Is the reef within a Green *or* Pink Zone of a Marine Protected Area?**
8. **Is the reef within dispersal range of coral larvae from a *robust* source reef?**[3]

7-8 VERY HIGH QUALITY
5-6 HIGH QUALITY
3-4 MEDIUM QUALITY
0-2 LOW QUALITY

Alternatively, if you have access to water quality *samples* or water quality data[4], you could allocate each reef a score for water quality using a **water quality index,** such as a **Q value**[5] and then incorporate the concept of connectivity into your research question!

[1] Nova Southeastern University (2019). *Tools and Resources.* NSU Accessed 09.04.2019 from: https://cnso.nova.edu/cpce/index.html (click on 'CPCe Download Request Form').
[2] Coral Watch (2019). *Data: Surveys*. Accessed 09.04.2019 from: https://coralwatch.org/index.php/data/surveys/
[3] Hock, K., Wolff, N.H., Ortiz, J.C., Condie, S.A., Anthony, K.R.N., Blackwell, P.G. and Mumby, P.J. (2017). Connectivity and systemic resilience of the Great Barrier Reef: **FIGURE 5**. *PLoS Biol 15(11): DOI: 10.1371/journal.pbio.2003355*
[4] eReefs (2019). *eReefs.* A collaboration between the GBR Foundation, BOM, CSIRO and AIMS. Accessed 09.04.2019 from: https://ereefs.org.au/ereefs
[5] Moffatt, B. (2019). *F45R Oceanography Study Guide.* Wet Paper Publications. Accessed 09.04.2019 from: http://www.wetpaper.com.au/media/F45ROceanographySample/176/

EXPERIMENTAL DESIGN

Name:

Date:

Study SITES

Over the next 4 worksheets, you have access to photo quadrats from the 4 reef locations listed below.

Activity: Give each reef a score for water quality by completing the table (refer to previous page for 'calculations')

Reef Location	Calculations	Score	Water Quality
(i) Agincourt Reef	0, 1, 1, 1, 1, 1, 1, 1	7	Very High Water Quality
(ii) Lady Elliot Island	0, 0, 1, 1, 1, 1, 1, 1	6	High Water Quality
(iii) Magnetic Island (Nelly Bay)	1, 0, 0, 0, 0, 1, 0, 1	3	Medium Water Quality
(iv) Sloping Island (Keppel Group)	1, 0, 0, 0, 0, 1, 0, 1,	3	Medium Water Quality

Activity: Complete Question 1 below. DISCUSS your hypotheses for both research questions.

Q1. Is there a difference in Mean Percentage Hard Coral Cover **between** Very High Water Quality (Agincourt Reef) **&** Medium Water Quality (Sloping Is) **?**

Q2. Is there a linear relationship between Mean Percentage Hard Coral Cover **&** Water Quality **?**

Controlled Variables

Controlled variables are all the variables that are kept the same (so they do not influence the outcome). E.g. what do all 4 reefs have in common? How were they the same when photographed and analysed?

Activity: List the controlled variables below

E.g. The photo quadrat method was used to photograph all 4 reefs
Random datum points A-J were used for all photo quadrats
All reefs were classed as tropical or sub-tropical reefs (no temperate reefs)
All reefs were within the boundaries of the Great Barrier Reef Marine Park

Measured Variables

If variables can *not* be controlled, they must be measured, so their influence can be considered in the outcome of the study. E.g. How were the reefs different to each other when photographed and analysed? ***Note*: Do not** include any differences that were part of the criteria/questions used for scoring water quality.

Activity: List the measured variables below

E.g. photo quadrats were in different *spatial and temporal scales* (e.g. resolution, area, size, date)
Photo quadrats were from different sources using different methods
Reef types were different (e.g. fringing reef vs coral cay)
Depths were different (e.g. Magnetic Is. and Sloping Is. much shallower)
Habitat Complexity (rugosity) different for all 4 reefs

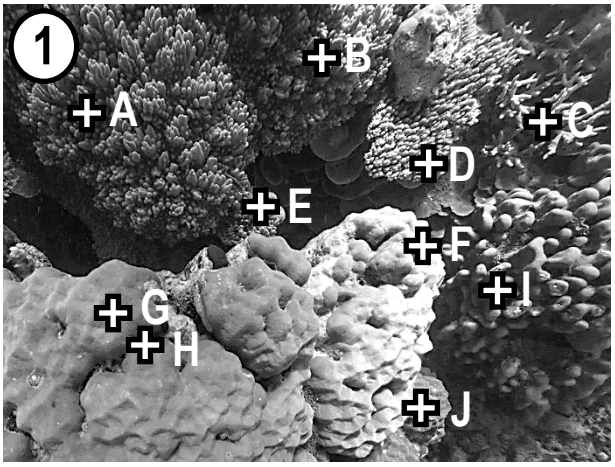
DATA COLLECTION: Example

Name:

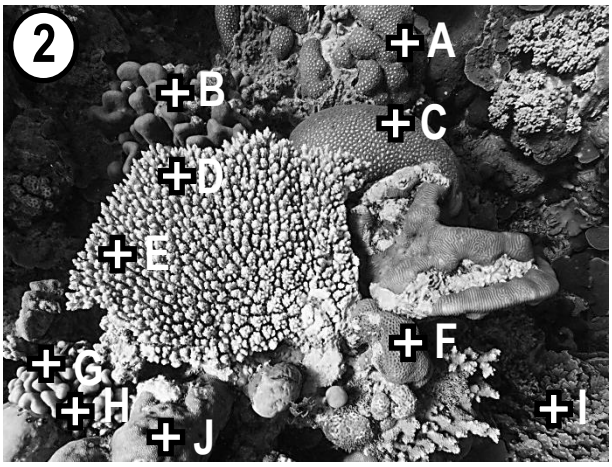
Date:

(i) Agincourt Reef

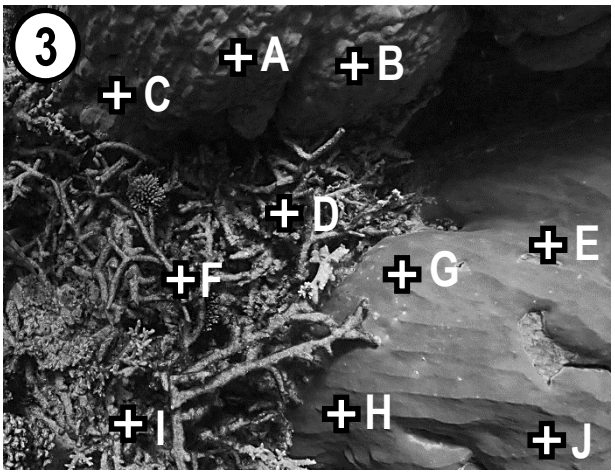
Original colour photos available on www.marineeducation.com.au (data)



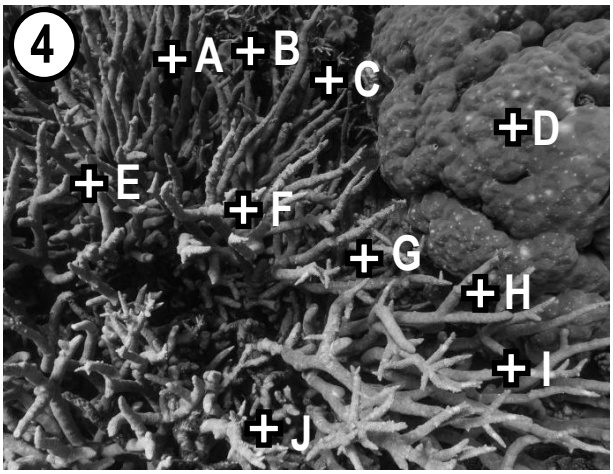
% hard coral cover: 100% (A-J)



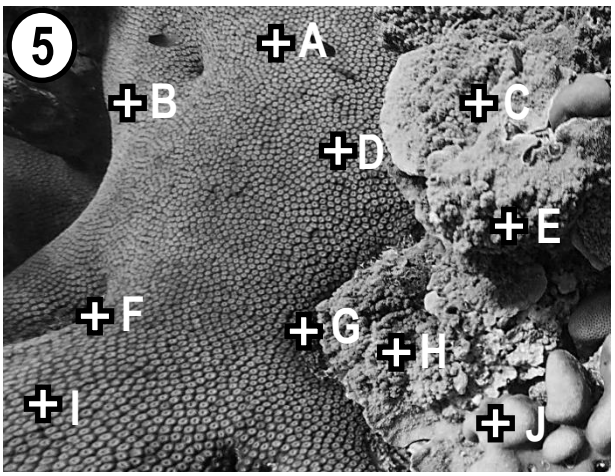
% hard coral cover: 100% (A-J)



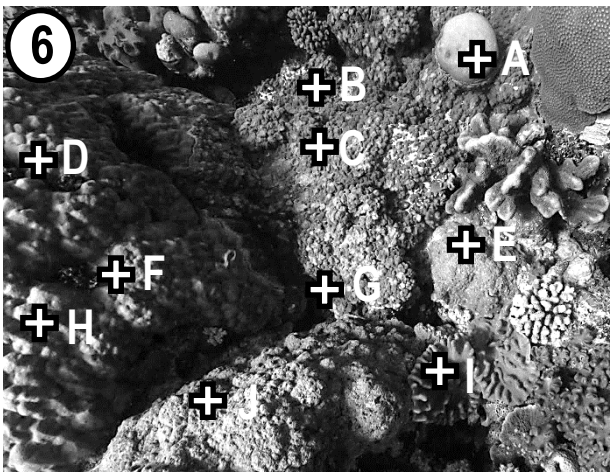
% hard coral cover: 70% (A,B,C,E,G,H,J)



% hard coral cover: 100% (A-J)



% hard coral cover: 100% (A-J)



% hard coral cover: 100% (A-J)

Images (of Agincourt Reef) sourced from the XL Catlin Global Reef Record. © Underwater Earth / XL Catlin Seaview Survey. Taken 23.11.2012. Accessed 24.01.2019 from www.catlinseaviewsurvey.com/ Datum points (A-J) were added at random.

marineeducation.com.au

Marine Education

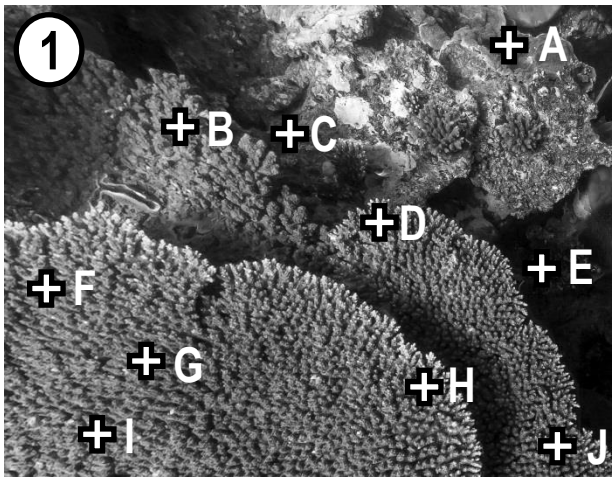
DATA COLLECTION

(ii) Lady Elliot Island

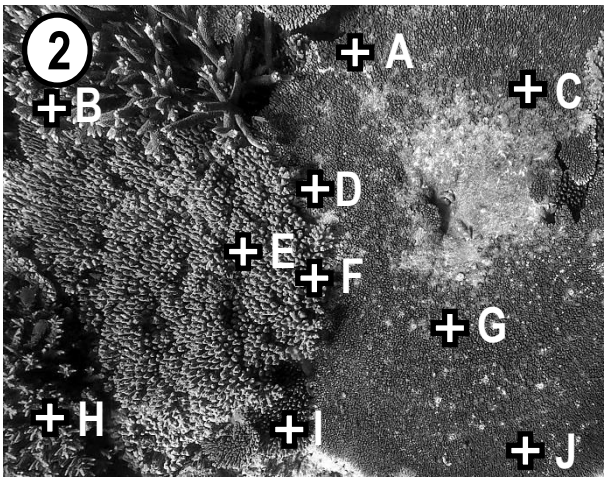
Name:

Date:

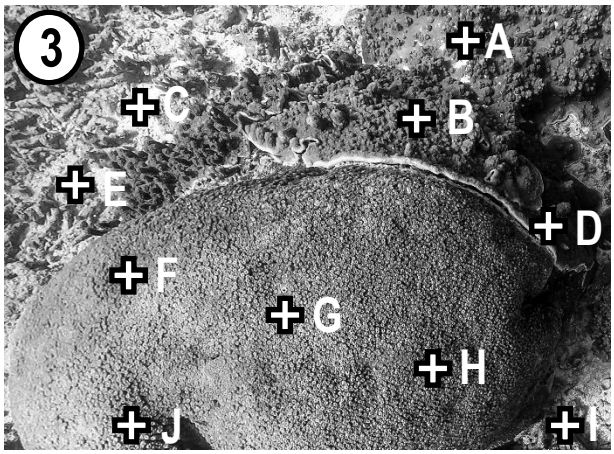
Activity: Estimate and record the percentage hard coral cover in each quadrat below



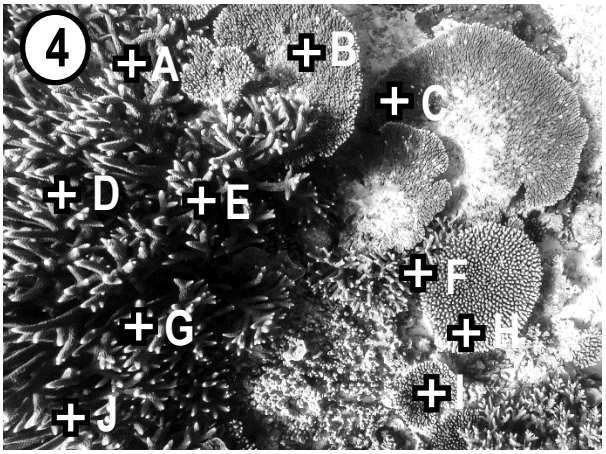
% hard coral cover: 80% (A,B,D,F,G,H,I,J)



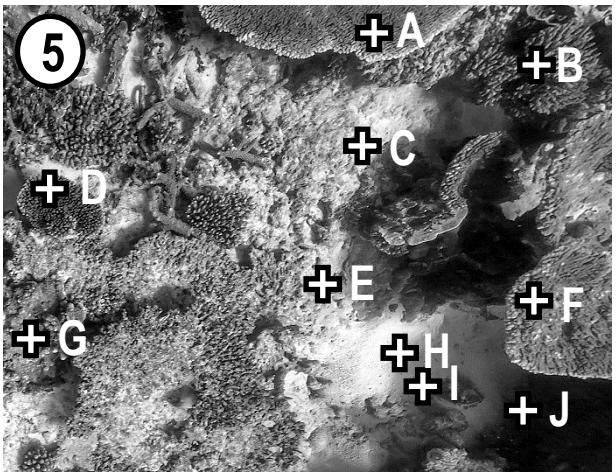
% hard coral cover: 100% (A-J)



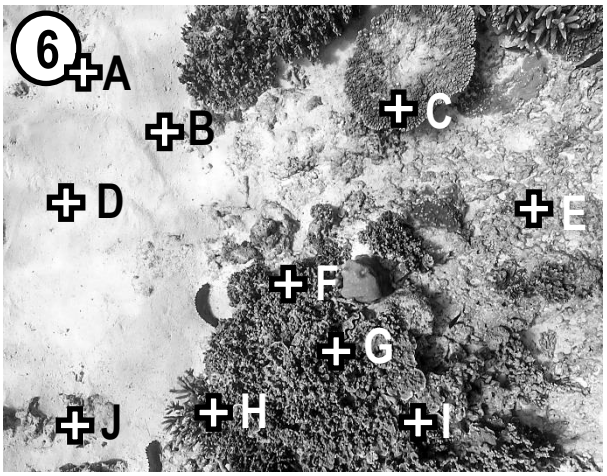
% hard coral cover: 70% (A,B,D,F,G,H,J)



% hard coral cover: 100% (A-J)



% hard coral cover: 50% (A,B,D,F,G)



% hard coral cover: 50% (C,F,G,H,I)

Images (of Lady Elliot Is.) sourced from the XL Catlin Global Reef Record. © Underwater Earth / XL Catlin Seaview Survey. Taken 29.06.2013. Accessed 24.01.2019 from www.catlinseaviewsurvey.com/ Datum points (A-J) were added at random.

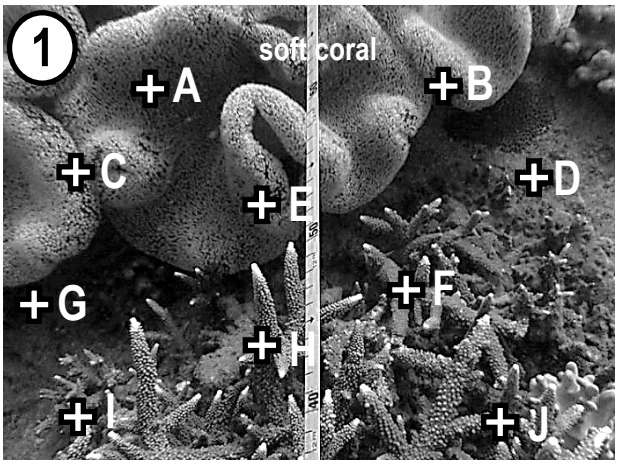
DATA COLLECTION

Name:

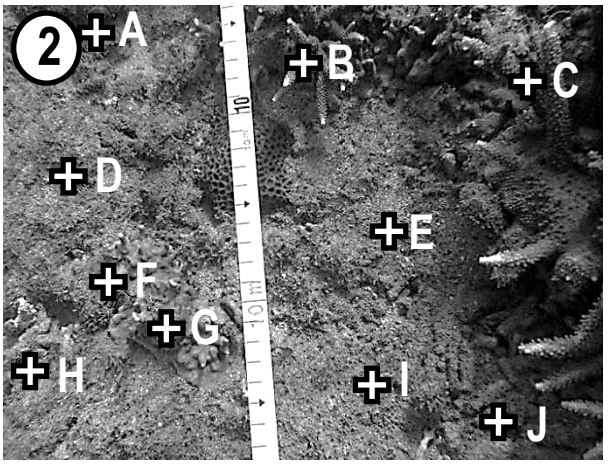
Date:

(iii) Magnetic Island (Nelly Bay)

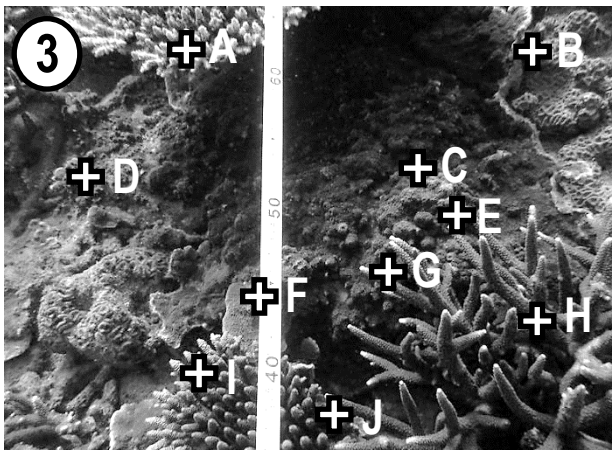
Activity: Estimate and record the percentage hard coral cover in each quadrat below



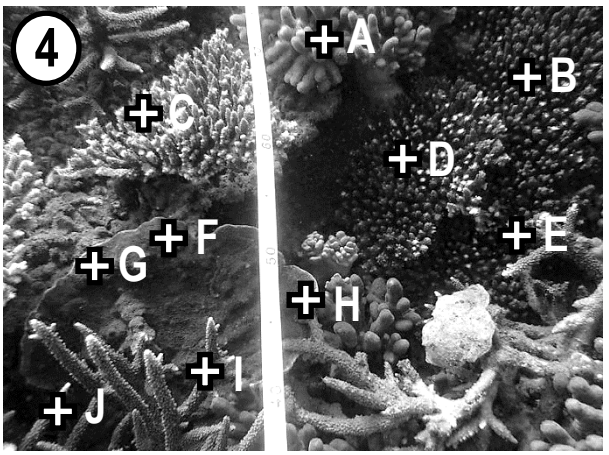
% hard coral cover: 40% (F,H,I,J)



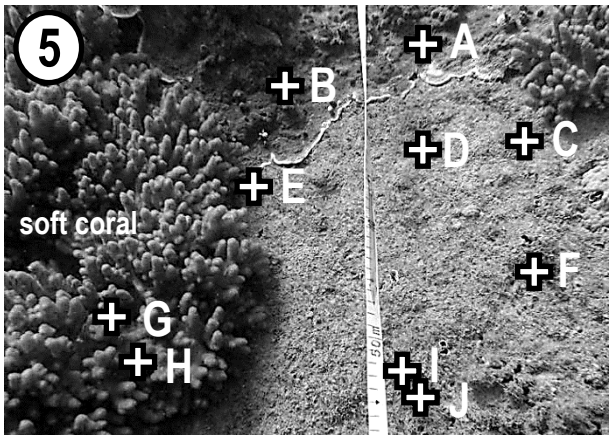
% hard coral cover: 20% (B,C)



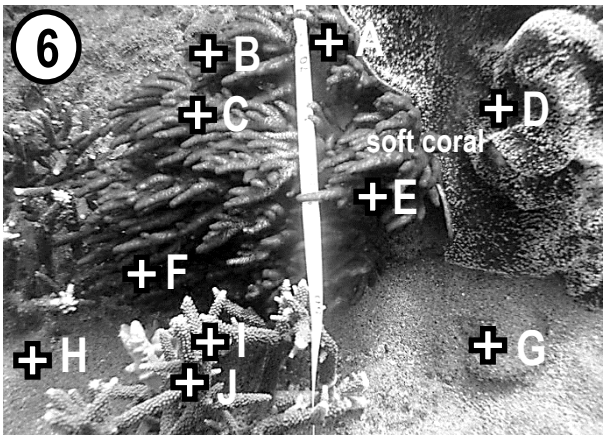
% hard coral cover: 100% (A-J)



% hard coral cover: 100% (A-J)



% hard coral cover: 20% (A,B)



% hard coral cover: 20% (I,J)

Photographs adapted from screenshots from Reef Life Survey Data Portal: Habitat Quadrats. Reprinted with permission. Date unknown. Accessed 24.01.2019 from www.reeflifesurvey.com/ All datum points (A-J) selected at random.

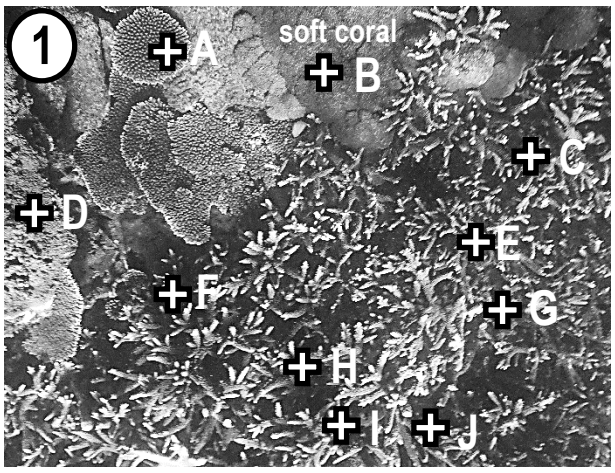
DATA COLLECTION

Name:

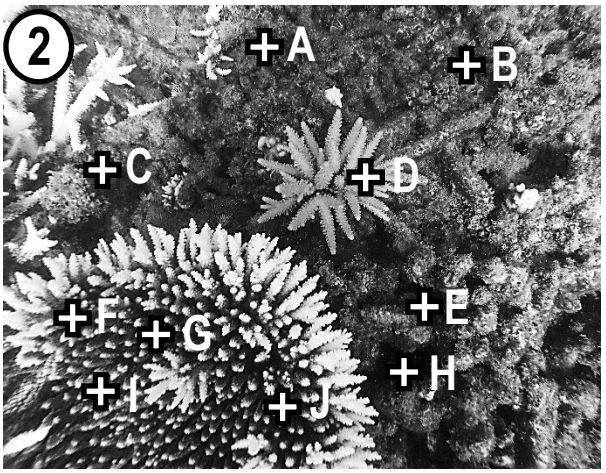
Date:

(iv) Sloping Island (Keppel Group)

Activity: Estimate and record the percentage hard coral cover in each quadrat below

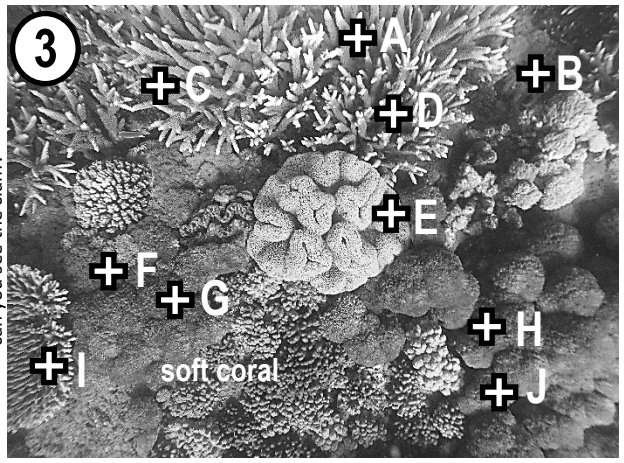


% hard coral cover: 90% (*A*,*C*,D,E,F,*G*,H,I,J)

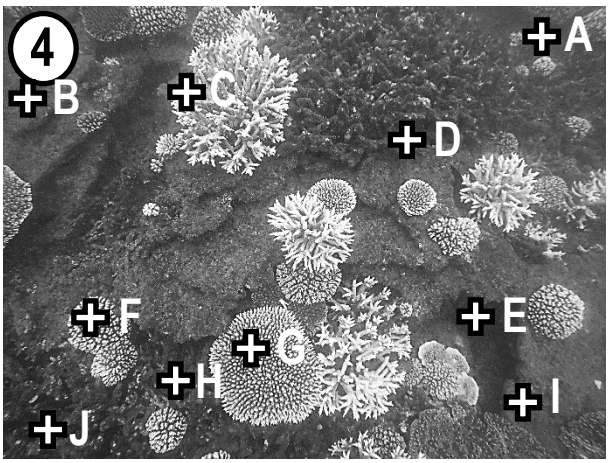


% hard coral cover: 50% (D,F,*G*,I,J)

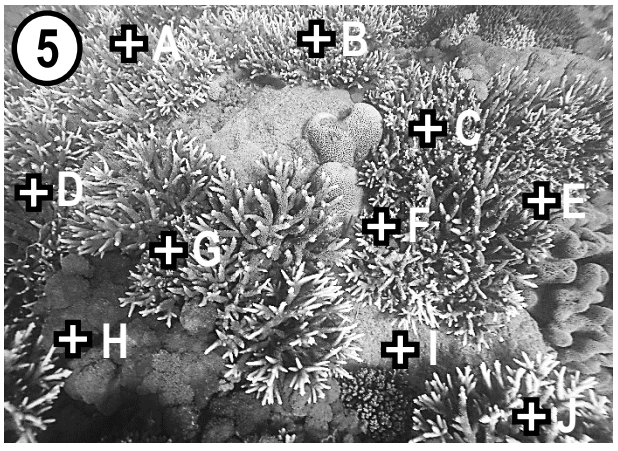
can you see the clam?



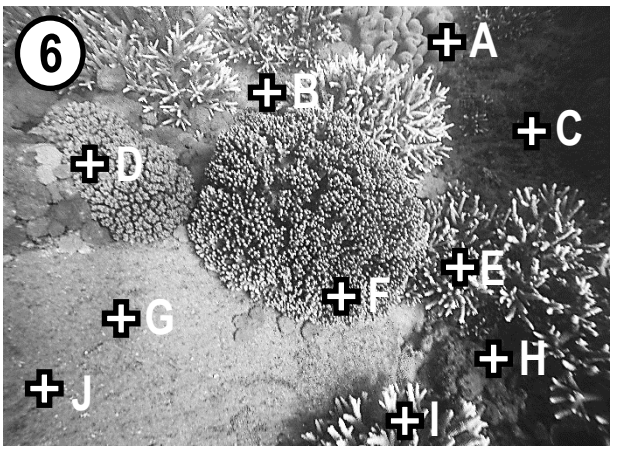
% hard coral cover: 40% (*A*,*C*,D,I)



% hard coral cover: 30% (*C*,F,*G*)



% hard coral cover: 80% (*A*,B,*C*,D,E,F,*G*,J)



% hard coral cover: 40% (D,E,F, I)

Photographs kindly provided by North Keppel Island Environmental Education Centre (found within the *Capricorn* GBRMPA Management Area). Date of photograph: Winter, 2018. Datum points (A-J) were selected at random.

DATA ANALYSIS
Results

Name:

Date:

Activity: Copy and complete the research questions from page 80 into the blank spaces below.

Q1. Is there a difference in Mean Percentage Hard Coral Cover **between** V. High Water Quality (Agincourt Reef) **&** Medium Water Quality (Sloping Island) **?**
Answer using a t-test (P-value)

Q2. Is there a linear relationship between y-axis: Mean Percentage Hard Coral Cover **&** x-axis: Water Quality **?**
Answer using a Pearson's correlation test (r-value)

Activity: Use your answers from the previous worksheets to complete the Results Table below

Excel cells	A	B	C	D	E	F	G	H	I	J	K
1	Reef Location	Water quality score	Percentage Hard Coral Cover						Mean	Standard Deviation (s)	Confidence Interval (CI)
2			①	②	③	④	⑤	⑥			
3	(i) Agincourt Reef	7	100	100	70	100	100	100	=AVERAGE(C3:H3) 95.0	=STDEV(C3:H3) 12.25	=CONFIDENCE.T(0.05,J3,6) 12.85
4	(ii) Lady Elliot Is	6	80	100	70	100	50	50	75.0	22.58	23.70
5	(iii) Magnetic Is	3	40	20	100	100	20	20	50.0	39.50	41.45
6	(iv) Sloping Is	3	90	50	40	30	80	40	55.0	24.29	25.49

To calculate the **mean, s,** and **CI**, in Microsoft Excel, start by entering values from ①②③④⑤⑥ in to cells C3-H6. Starting with Agincourt Reef, in cell I3, type the formula: **=AVERAGE(C3:H3)** In cell J3, type the formula: **=STDEV(C3:H3)** And, in cell K3, type the formula: **=CONFIDENCE.T(0.05,J3,6)** Repeat for the other reefs, substituting the 3 in the formulas for 4, 5 and 6. Alternatively, just drag down the tiny square on the bottom right-hand corner of cell I3, J3 and K3.

Complete the table to find a P-value for Q1

Q1	QUADRATS ①②③④⑤⑥	P
(i) Agincourt Reef	100,100,70,100,100,100	0.0048
(iv) Sloping Is	90,50,40,30,80,40	

To calculate the P-value, google **GraphPad QuickCalcs: t test calculator.** Enter data for Agincourt Reef in to the Group 1 column. Enter data for Great Keppel Island in to the Group 2 column. Select unpaired test and click 'Calculate Now'. If the P-value is =< 0.05, the difference is significant.

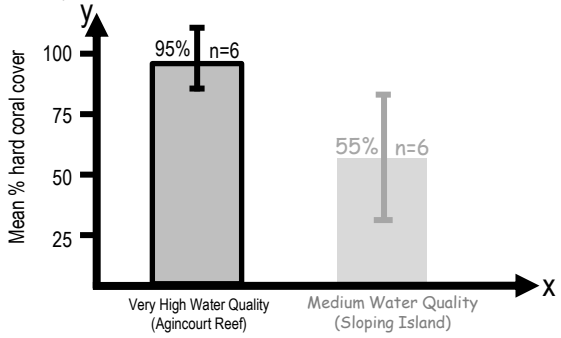
Complete the table to find a r-value for Q2

Q2 Reef Locations →		(i)	(ii)	(iii)	(iv)	r
y-axis	Mean % hard coral cover *hint:* Column I	95	75	50	55	0.97298
x-axis	Water Quality Score *hint:* Column B	7	6	3	3	

To calculate the r-value, in Excel, enter the water quality scores in to cells B3-B6. Then, click on any blank cell in Excel and type the formula: **=CORREL(I3:I6,B3:B6)** comma ! If the r value is between 0.5 and 1.0 or between -0.5 and -1.0, a *linear* relationship exists. The closer the r value is to ±1.0, the stronger the relationship.

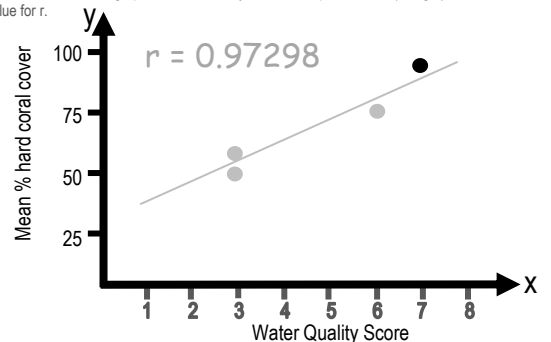
Complete the Bar graph for Q1 Results

Note: the *top* of the error bar is the mean + CI. Whilst, the *bottom* of the error bar is the mean - CI



Complete the scatter plot for Q2 Results

Note: Create a dot on the graph for each x and y co-ordinate pair. Draw a (straight) line of best fit and write the value for r.



Answer to research question 1? [Yes] [No]

Answer to research question 2? [Yes] [No]

INTERPRETATION and EVALUATION

Name:

Date:

Activity: Analyse the evidence (i.e. results) to identify trends, patterns or relationships.

As water quality increases, reef health increases (and vice versa).

Activity: Analyse the evidence (i.e. methods and results) to identify uncertainty and limitations

Number of quadrats per site (6) not enough. Also, not enough reefs and not enough datum points per photo quadrat. Standard deviations were too high. Photo quadrats were from various online sources using different methods. Method used to calculate water quality (i.e. questions) were simply made up.

Activity: Interpret the evidence (i.e. results) to draw conclusion/s to the research questions

Q1. There was a significant difference in percentage hard coral cover between *Very High* water quality (Agincourt) and *Medium* water quality (Sloping Is.). The *null* hypothesis was rejected (P=0.0048).
Q2. There was a strong linear relationship between mean percentage hard coral cover and water quality. The *null* hypothesis was rejected (r=0.97298).

Note: the null hypothesis always states there is no difference or no relationship between this and that.

Activity: Evaluate the reliability and validity of the experimental process

Reliability: Needed more replicates. 's' & 'CI' were too high and 'n' was too low.
Validity: accuracy compromised by uncertainties and limitations listed above.
Revisit measured variables and their influence on the outcome of the study.

Activity: Suggest possible improvements and extensions to the experiment

- Increase the number of replicates (i.e. reefs, photo quadrats, datum points)
- Collect dependent and independent data at the same time (e.g. go to Keppel)
- Keep the AREA of each photo quadrat the same (e.g. 1m x 1m).
- Base criteria/questions used to score water quality on scientific research.

Activity: *Plan* and *justify* a modification of the research question and methodology.

- Add coral watch data (i.e. for more information to add to your analysis).
- Change or add locations (e.g. more locations will give you more plots to add to Pearson's correlation analysis).
- Change criteria/questions when scoring water quality (validated by science).
- Use a water quality index (e.g. Q-value) instead of criteria/questions
- See previous suggestions for possible improvements and extensions.