Marine Science 2019 v1.2

IA2 high-level annotated sample response

July 2018

Student experiment (20%)

This sample has been compiled by the QCAA to assist and support teachers to match evidence in student responses to the characteristics described in the instrument-specific marking guide (ISMG).

Assessment objectives

This assessment instrument is used to determine student achievement in the following objectives:

2. apply understanding of the reef and beyond or changes on the reef to modify experimental methodologies and process primary data
3. analyse experimental evidence about the reef and beyond or changes on the reef
4. interpret experimental evidence about the reef and beyond or changes on the reef
5. investigate phenomena associated with the reef and beyond or changes on the reef through an experiment
6. evaluate experimental processes and conclusions about the reef and beyond or changes on the reef
7. communicate understandings and experimental findings, arguments and conclusions about the reef and beyond or changes on the reef.

Note: Objective 1 is not assessed in this instrument.

Instrument-specific marking guide (ISMG)

Criterion: Research and planning

Assessment objectives

2. apply understanding of the reef and beyond or changes on the reef to modify experimental methodologies and process primary data
5. investigate phenomena associated with the reef and beyond or changes on the reef through an experiment

The student work has the following characteristics:	Marks
• informed application of understanding of the reef and beyond or changes on the reef to modify experimental methodologies demonstrated by - a considered rationale for the experiment - justified modifications to the methodology • effective and efficient investigation of phenomena associated with the reef and beyond or changes on the reef demonstrated by - a specific and relevant research question - a methodology that enables the collection of sufficient, relevant data - considered management of risks and ethical or environmental issues.	5–6
• adequate application of understanding of the reef and beyond or changes on the reef to modify experimental methodologies demonstrated by - a reasonable rationale for the experiment - feasible modifications to the methodology • effective investigation of phenomena associated with the reef and beyond or changes on the reef demonstrated by - a relevant research question - a methodology that enables the collection of relevant data - management of risks and ethical or environmental issues.	3–4
• rudimentary application of understanding of the reef and beyond or changes on the reef to modify experimental methodologies demonstrated by - a vague or irrelevant rationale for the experiment - inappropriate modifications to the methodology • ineffective investigation of phenomena associated with the reef and beyond or changes on the reef demonstrated by - an inappropriate research question - a methodology that causes the collection of insufficient and irrelevant data - inadequate management of risks and ethical or environmental issues.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Analysis of evidence

Assessment objectives

2. apply understanding of the reef and beyond or changes on the reef to modify experimental methodologies and process primary data
3. analyse experimental evidence about the reef and beyond or changes on the reef
5. investigate phenomena associated with the reef and beyond or changes on the reef through an experiment

The student work has the following characteristics:	Marks
• appropriate application of algorithms, visual and graphical representations of data about the reef and beyond or changes on the reef demonstrated by correct and relevant processing of data • systematic and effective analysis of experimental evidence about the reef and beyond or changes on the reef demonstrated by - thorough identification of relevant trends, patterns or relationships - thorough and appropriate identification of the uncertainty and limitations of evidence • effective and efficient investigation of phenomena associated with the reef and beyond or changes on the reef demonstrated by the collection of sufficient and relevant raw data.	5–6
• adequate application of algorithms, visual and graphical representations of data about the reef and beyond or changes on the reef demonstrated by basic processing of data • effective analysis of experimental evidence about the reef and beyond or changes on the reef demonstrated by - identification of obvious trends, patterns or relationships - basic identification of uncertainty and limitations of evidence • effective investigation of phenomena associated with the reef and beyond or changes on the reef demonstrated by the collection of relevant raw data.	3–4
• rudimentary application of algorithms, visual and graphical representations of data about the reef and beyond or changes on the reef demonstrated by incorrect or irrelevant processing of data • ineffective analysis of experimental evidence about the reef and beyond or changes on the reef demonstrated by - identification of incorrect or irrelevant trends, patterns or relationships - incorrect or insufficient identification of uncertainty and limitations of evidence • ineffective investigation of phenomena associated with the reef and beyond or changes on the reef demonstrated by the collection of insufficient and irrelevant raw data.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Interpretation and evaluation

Assessment objectives

4. interpret experimental evidence about the reef and beyond or changes on the reef
6. evaluate experimental processes and conclusions about the reef and beyond or changes on the reef

The student work has the following characteristics:	Marks
• insightful interpretation of experimental evidence about the reef and beyond or changes on the reef demonstrated by justified conclusion/s linked to the research question • critical evaluation of experimental processes about the reef and beyond or changes on the reef demonstrated by - justified discussion of the reliability and validity of the experimental process - suggested improvements and extensions to the experiment that are logically derived from the analysis of evidence.	5–6
• adequate interpretation of experimental evidence about the reef and beyond or changes on the reef demonstrated by reasonable conclusion/s relevant to the research question • basic evaluation of experimental processes about the reef and beyond or changes on the reef demonstrated by - reasonable description of the reliability and validity of the experimental process - suggested improvements and extensions to the experiment that are related to the analysis of evidence.	3–4
• invalid interpretation of experimental evidence about the reef and beyond or changes on the reef demonstrated by inappropriate or irrelevant conclusion/s • superficial evaluation of experimental processes about the reef and beyond or changes on the reef demonstrated by - cursory or simplistic statements about the reliability and validity of the experimental process - ineffective or irrelevant suggestions.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Communication

Assessment objective

7. communicate understandings and experimental findings, arguments and conclusions about the reef and beyond or changes on the reef

The student work has the following characteristics:	Marks
• effective communication of understandings and experimental findings, arguments and conclusions about the reef and beyond or changes on the reef demonstrated by - fluent and concise use of scientific language and representations - appropriate use of genre conventions - acknowledgment of sources of information through appropriate use of referencing conventions.	2
• adequate communication of understandings and experimental findings, arguments and conclusions about the reef and beyond or changes on the reef demonstrated by - competent use of scientific language and representations - use of basic genre conventions - use of basic referencing conventions.	1
• does not satisfy any of the descriptors above.	0

Task

Context
You have completed the following practicals in class: • Examine coral diversity using a transect technique (using online or field data) (suggested practical). • Investigate the effects an altered ocean pH has on marine carbonate structures (mandatory practical).
Task
Modify (i.e. refine, extend or redirect) an experiment in order to address your own related hypothesis or question. You may use a practical performed in class, a related simulation or another practical related to Unit 3 (as negotiated with your teacher) as the basis for your methodology and research question.

Sample response

Criterion	Marks allocated	Result
Research and planning Assessment objectives 2, 5	6	5
Analysis of evidence Assessment objectives 2, 3, 5	6	6
Interpretation and evaluation Assessment objectives 4, 6	6	6
Communication Assessment objective 7	2	2
Total	**20**	**19**

The annotations show the match to the instrument-specific marking guide (ISMG) performance-level descriptors.

Key: Research and planning | Analysis of evidence | Interpretation and evaluation | Communication

Note: Colour shadings show the characteristics evident in the response for each criterion.

Communication [2] **acknowledgment of sources of information through appropriate use of referencing conventions** The use of in-text referencing fits the purpose of a scientific report. **Research and planning [5–6]** **a considered rationale for the experiment** The rationale contains evidence of a logical, scientifically informed basis for the experiment.	**Rationale** Coral reefs are an important marine habitat type for many fish and invertebrate species (Connell 1978). The Great Barrier Reef is one of the greatest areas in biodiversity in the world. Additionally, the Great Barrier Reef has several environmental and economic benefits (Moberg & Folke 1999). Reef structures help to protect shorelines from erosion and storm surges, and it is estimated that coral reefs are worth over $350,000 per hectare per year (Costanza et al. 2014). The majority of this economic benefit comes from recreational and commercial fishing and tourism. The Great Barrier Reef Catchment has a substantial amount of sugar cane farming which often uses fertilisers containing dissolved inorganic nitrogen (DIN). Excess fertiliser or topsoil containing fertiliser, can be washed into the Great Barrier Reef lagoons making it readily available for plant life (Webster et al., 2012). The increase in dissolved inorganic nitrogen can affect water quality and the algal community of the reefs. In the water, the excess nitrogen can also cause blooms of phytoplankton (Lapointe et al., 2005). The increased amount of phytoplankton can decrease water clarity and limit photosynthesis of the coral's zooxanthellae. Prolonged periods of decreased photosynthesis in the zooxanthellae can ultimately result in coral death (Roth 2014). Coral reef systems do need to contain some algae because it is an important food source for many fish and invertebrates. Additionally, some algal species contain calcium carbonate and as the algae die or are consumed; the calcium carbonate helps to fuse pieces of coral together into a larger reef structure (Castro & Huber 2010). However, if there is too much algae on a reef it can be an indicator of high nutrient (nitrogen and phosphorous) levels in the water (Birrell, McCook & Willis 2005). Additionally, algae compete for space with

coral, and especially new coral settling on a reef. Therefore, as benthic algae can quickly colonise dead coral surfaces, it may limit the ability of the reef to keep growing (Diaz-Pulido & McCook 2002). Consequently, a good indicator of health in a coral reef system could be assessing the amount of living coral and the amount of algae.

As the coral dies, there is more space on the reef for algae to colonize and grow. Therefore, the reefs where coral is dying may show a shift from a coral community to an algal community (Birrell, McCook & Willis 2005). Additionally, if the water has high levels of nitrogen and phosphorous in the water this will act as a fertilizer for the algae on the reef. This results in an increase in algal biomass on the reef (Lapointe et al. 2005). Finally, the increased algal cover on the reef makes it difficult for the reef to recover, even if the water quality improves. The algae take up space on the reef and that limits the ability of the coral larvae to settle on the reef and regrow new reef (McCook 2001). Therefore, it is unlikely that these areas will recover quickly from any disturbances.

As many of the impacts on coral reefs come from humans, it would be expected that coral reefs closer to large population centres would show greater impacts. This lead to the question of examining coral reef health in reefs near and far from the coast of mainland Australia.

Research and planning [3–4]

a relevant research question

The research question is connected to the rationale and allows the effective investigation of Topic 1: The reef and beyond (Coral reef distribution) in the *Marine Science 2019* syllabus. However, the response does not specifically identify the independent variable or the dependent variable.

Research question

Does the amount of living coral on a reef increase with distance from the coast?

Due to the difficulty in identifying coral and algae to species level some assumptions were made in conducting the experiment to address the research question. It was assumed that the coral counted (due to the branching morphology observed) was in the Acropora genus and that the algae observed was a form of turf algae.

Original experiment

The original experiment (from the class fieldwork booklet based on Methods for ecological monitoring of coral reefs) was a benthic distribution study at Heron Island. It used a 10m transect from shore (at low tide) with 1m x 1m quadrats every 2m. Site selection was based on the leeward side of the island. Transect positions were chosen randomly (using Google maps and a random number generator) prior to conducting the experiment.

Modifications to the methodology

Convenience sampling was used to select two locations from the online reef database (www.globalreefrecord.org). One location was a reef near the coast (less than 10km), and the other location was far from the coast (more than 50km). This was to ensure the research question could be addressed. To ensure that sufficient, relevant data was collected the original experiment was changed to increase the number of samples and measurements, as the original experiment had a small sample size.

Research and planning [5–6]

a methodology that enables the collection of sufficient, relevant data

The methodology shows careful and deliberate thought. It enables collection of adequate data so an informed conclusion to the research question can be drawn.

justified modifications to the methodology

The response gives sound reasons for how the modifications to the methodology will refine, extend or redirect the original experiment.

considered management of risks and ethical or environmental issues

The response shows careful and deliberate identification and planning to handle risks and ethical or environmental issues in the experiment.

Consequently 10 random 1m x 1m photographic quadrats were chosen along the transect at each location. The random selection of quadrats was used to minimise sample bias. The increase in sample size allowed the calculation of a mean, standard error and confidence intervals. Allowing the data to be extrapolated to a population.

As an indirect method was used to establish coral health the experiment was modified to improve the reliability and validity of the data. This was addressed through using a

- 100-point grid over each photographic quadrat. The substrate directly below each intercept was identified to give percentage cover of each substrate type. For simplicity, each intercept counted as the whole 1%, regardless of what was in the adjoining squares. This allowed for more precise data to be collected.
- Each image of living colour was also interpreted using a coral health chart (www.coralwatch.org/web/guest/coral-health-chart) and assigned a coral colour score. This allowed for quantifiable qualitative data to be collected to ascertain if the coral could be included in the sample.

Identified variables included:

- **Independent variable (IV):** location of the reef (distance from shore in km)
- **Dependent variable (DV):** substrate type (living coral or dead coral/algae)
- **Controlled variables (CV):** quadrat size, survey, technique, date, image resolution
- **Monitored variables (MV):** weather, time and tide cycle, previous storm activity, visibility

Safety and ethical considerations

Conducting this experiment virtually means that possible safety and ethical considerations (e.g. use of snorkelling equipment, damage to the reef) were avoided.

Processed data

For the analysis of this experiment the following data processing occurred:

- the mean was chosen as the most appropriate measure of central tendency
- standard deviation was calculated as a measure of spread and used to calculate standard error
- standard error was chosen as a measure of uncertainty and
- a confidence interval was chosen as a measure of reliability.

Analysis of evidence [5–6]

correct and relevant processing of data

Raw data is manipulated accurately to provide evidence that is applicable to the research question.

Table 1: Sample calculations

Calculation	Example
Mean percentage living coral	Mean was calculated in excel by using the AVERAGE function μ (near shore) = $\frac{10+20+24+28+30+15+18+32+27+29}{10}$ μ = 23.3 %
Frequency (coral scores)	Frequency was calculated in excel by using the COUNT function f = n(near shore, coral score 3) f = 4
Standard deviation for a sample population	Standard deviation (s) was calculated in excel by using the STDEV function. s (near shore, live coral)= 7.3
Standard error	Standard error was calculated in excel by dividing the standard deviation by the square root of the sample size. $SE_{\bar{X}} = \frac{s}{\sqrt{n}}$ $SE_{\bar{X}} = \frac{7.3}{\sqrt{10}}$ $SE_{\bar{X}} = 2.3$ where $SE_{\bar{X}}$ is the standard error of the mean *s* is the sample standard deviation and *n* is the size (number of scores) in a sample.
Confidence interval	*A confidence interval of 95% was calculated in excel using the CONFIDENCE.T function* $CI\ (95\%) = (0.05, s, n)\ \ CI\ (95\%) = (0.05, 7.3, 10)$ $CI\ (95\%) = 5.2$ where CI is the confidence interval *s* is the sample standard deviation and *n* is the size (number of scores) in a sample.

Analysis of evidence

[5–6]

collection of sufficient and relevant raw data

The raw data is adequate for forming a conclusion and has direct bearing upon the research question.

Communication [2]

appropriate use of genre conventions

Raw data is recorded with the associated uncertainties and expressed consistently to the correct number of significant figures.

The response uses units and symbols correctly.

Table 2: Percentage cover of living coral and dead coral/algae at near shore and off shore locations. Percentages are based on 100-point intercept grids overlaying 1m x 1m photo quadrats.

Reef location	Sample	Percentage cover living coral (%)	Percentage cover algae (%)	Coral colour score (live coral only)
Near shore (10 km)	1	10	80	2
	2	20	75	3
	3	24	70	3
	4	28	68	4
	5	30	70	4
	6	15	80	3
	7	18	65	2
	8	32	60	4
	9	27	50	4
	10	29	68	3
	Mean	23.3	68.6	3.2
	s	7.3	9.1	
	Standard error	2.3	2.9	
	Confidence interval	5.2	6.5	
Off shore (50 km)	1	50	45	4
	2	75	20	4
	3	67	25	5
	4	60	34	5
	5	70	22	5
	6	72	25	4
	7	60	37	6
	8	66	22	6
	9	58	40	3
	10	69	31	5
	Mean	64.7	30.1	4.7
	s	7.6	8.6	
	Standard error	2.4	2.7	
	Confidence interval	5.4	6.2	

Communication [2]

fluent and concise use of scientific language and representations

The response represents data in an appropriate format to ensure that the trends, patterns and relationships can be accurately interpreted.

Analysis of evidence [5–6]

thorough identification of relevant trends, patterns or relationships

The identified trends, patterns and relationships are not superficial and allow a justified conclusion to the research question to be drawn.

thorough and appropriate identification of the uncertainty and limitations of evidence

The response suitably recognises and states the uncertainty and limitations of the data in a way that is not superficial or partial.

The response examines the uncertainty to determine if the evidence that will be used to draw a conclusion to the research question is reliable and valid.

The data shows the mean percentage cover of the near shore reef was within the range of 21.0 – 25.6% whilst the offshore was 62.3 – 67.1%. The standard error has been used a measure of the uncertainty associated with these averages (±SE). The standard error suggests that there is some imprecision in the data collection process. However the similarity of the SE indicates that there was similarity in the methodology used.

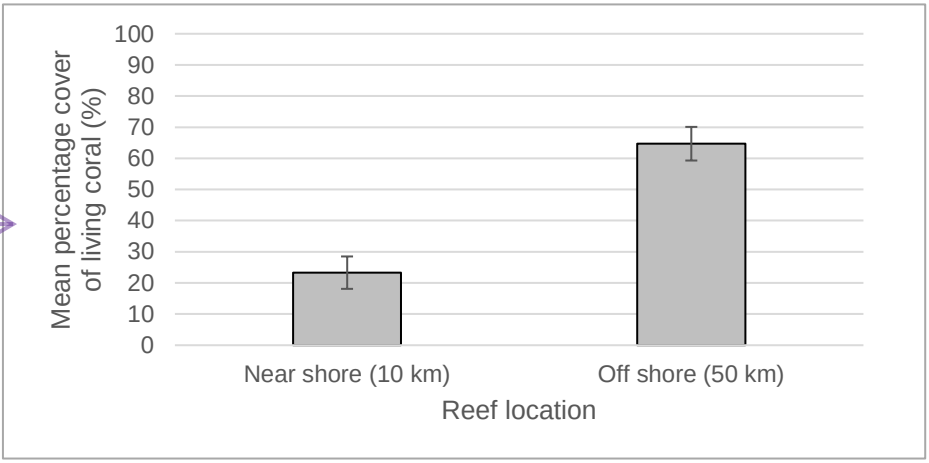

Figure 1: Mean percentage of living coral (confidence intervals presented as error bars) at near shore and off shore coral reef locations.

The off shore location shows a 41.4% increase in the sample mean (percentage living coral cover) compared to the near shore location. This suggests that there is a greater amount of living coral further from shore.

Analysis: The data indicates, with 95% confidence that the sample mean (percentage cover of living coral) falls within 18.1 – 28.5% for the near shore reef and 59.3 – 70.1% for the offshore reef. As there is no overlap in the error bars (confidence intervals) this indicates that there is a statistical difference between the two means. Therefore, it can be suggested with confidence that distance has a significant positive effect on the amount of live coral present.

Communication [2]

fluent and concise use of scientific language and representations

The response represents data in an appropriate format to ensure that the trends, patterns and relationships can be accurately interpreted.

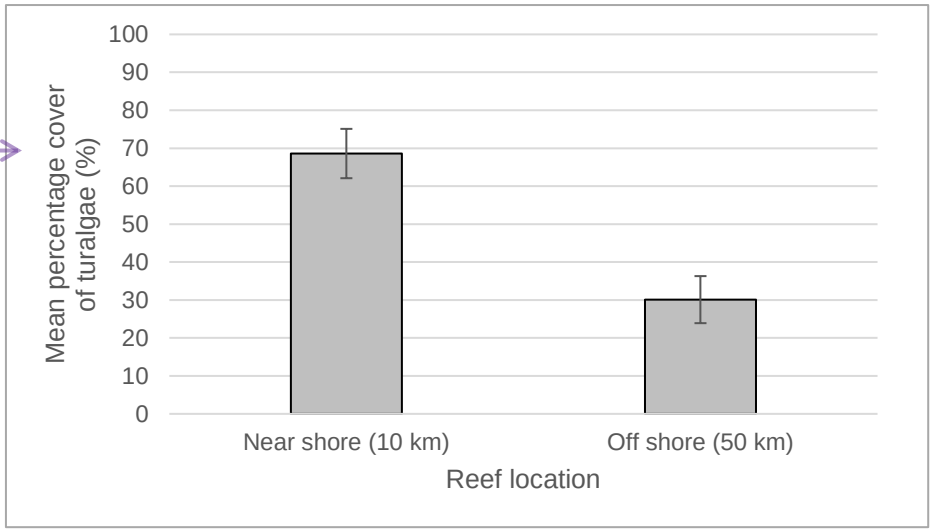

Figure 2: Mean percentage of algae (error bars represented as confidence intervals) at near shore and off shore coral reef locations.

Analysis of evidence [5–6]

thorough identification of relevant trends, patterns or relationships

The response identifies trends, patterns or relationships that are applicable to the research question.

The off shore location shows a 38.5% decrease in the sample mean (percentage algal cover) compared to the near shore location. These results suggest that there is a greater amount of algae in near shore environments.

thorough and appropriate identification of the uncertainty and limitations of evidence

The response suitably identifies uncertainty and limitations of the data in a way that is not superficial or partial. The response examines the uncertainty to determine if the evidence that will be used to draw a conclusion to the research question is reliable and valid.

Analysis: The data indicates, with 95% confidence that the sample mean (percentage cover of algae) falls within 62.1 – 75.1% for the near shore reef and 22.9 – 36.3% for the offshore reef. As there is no overlap in the error bars (confidence intervals) this indicates that there is a statistical difference between the two means. Therefore, it can be suggested with confidence that distance has a significant negative effect on the amount of algae present.

Communication [2]

fluent and concise use of scientific language and representations

The response represents data in an appropriate format to ensure that the trends, patterns and relationships can be accurately interpreted.

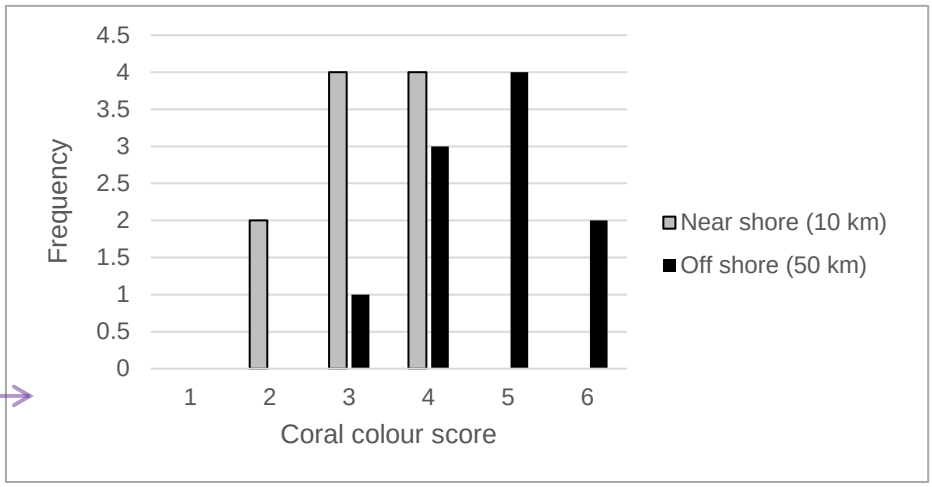

Figure 3: Frequency of coral colour score of near shore and off shore reef locations.

Analysis of evidence [5–6] **thorough identification of relevant trends, patterns or relationships** The response identifies trends, patterns or relationships that are applicable to the research question.	The frequency of coral scores for the off-shore reef is more positively skewed than the near shore reefs. The mode is higher for the off-shore reef at a coral colour score of 5 compared to 3 for the near shore reef. **Analysis:** As this data is based on qualitative measurements a mathematically analysis was not chosen for this data. However, the higher coral score (based on the mode) indicates that the amount of living coral present in the off-shore reef is healthier than the near shore. Further research (see extensions) could be considered based on this data. **Evaluation** **Limitations of the evidence** This study examined the influence of reef location on living coral and algal amount. Confounding variables were controlled where possible. The uncertainty in the data, represented by the standard error and confidence intervals, can be explained by a lack of reliability and validity in the experimental process.
thorough and appropriate identification of the uncertainty and limitations of evidence The response suitably recognises and states the uncertainty and limitations of the data in a way that is not superficial or partial. The response examines the uncertainty to determine if the evidence that will be used to draw a conclusion to the research question is reliable and valid.	The standard error calculated in this experiment appears to be low, suggesting the data obtained is reliable. However, the low sample size of this experiment is a major factor in determining the range of the confidence intervals (refer to Table 1 and Figure 1). The confidence intervals are larger in the algae cover data compared to the living coral cover data. This indicates that there is more confidence in the mean of the living coral data. One possible explanation for this is that the experimenter was biased in assigning values to live coral. If this is the case then the evidence has limited ability to be used to extrapolate the findings of the experiment to the population of corals (Acropora spp.) on the two reefs examined. No outliers (valid extreme values) were visually observed in the data. However, this was not confirmed mathematically, consequently the mean reported may have altered the results of the data analysis.
Interpretation and evaluation [5–6] **justified discussion of the reliability and validity of the experimental process** The response uses sound reasoning and evidence from the identification of uncertainties and limitations to support the consideration of the reliability and validity of the experimental process.	**Sources of error** ***Effecting reliability*** • Confounding variables could not be minimised in this experiment and therefore it cannot be known which additional abiotic and biotic factors affected the percentage cover of living coral. • Whilst there was random selection within the quadrats, convenience sampling was chosen for the selection of two sites. This could explain some of the remaining imprecision in the data (i.e. consider standard error, Table 1). • The image resolution of the photograph, used to measure the percentage cover, is poor and the grid lines placed on the photograph were imprecise. The precision of this camera (XL Catlin Seaview SVII) was not identified on the website. However it is assumed that this contributes to the coral percentage data being imprecise.

Effecting validity

- The benthic percentage cover is determined indirectly. The standard deviation of the data suggests that this technique could contribute to the variability in the data.
- The visibility of the photograph limits the experimenter in interpreting the data. This introduced bias therefore could contribute to the data being inaccurate.

Suggested improvements and extensions

Suggested improvements

Reducing the random error in the experimental process would improve its reliability. In this experiment, the reliability of the data could be improved by increasing the number of repeat readings of each sample, increasing the number of samples and running the experiment (trial) more than once to decrease standard error.

To address the imprecision in the data a random selection technique for site location and a positive calibration of the human experimenter should be chosen to decrease the sample bias. This could improve both the reliability and the validity of the experimental process and would allow the results to be generalised to the Acropora spp. coral population.

The accuracy of the data could be improved by using a grid on the camera lens when initially taking the photograph. This would ensure that the virtual quadrat was placed as per an *in situ* experiment, rather than the experimenter adding the quadrat afterwards (increasing sample bias) thus increasing the validity of the experiment.

Suggested extensions

- **Extend** the experiment to consider before and after bleaching events, different types of coral, different reef locations, different reef distances.

Conclusion

In conclusion, the evidence suggests that the amount (percentage cover) of living coral on a reef increases with distance (10km and 50km) from the coast. The results of this study also suggest that there may be an impact of proximity to land on coral reef survivorship. The literature suggests that the increase in algae in near shore reefs is likely caused by nitrogen and phosphorous input from the cane farming in the Great Barrier Reef Catchment. Since the reef is unlikely to recover quickly from any nutrient-based disturbance, it is important to manage nutrient input into the Great Barrier Reef Catchment to prevent any potential disturbances.

Word count: 1847

Interpretation and evaluation [5–6]

suggested improvements and extensions to the experiment that are logically derived from the analysis of evidence

The response uses clear, sound reasoning to arrive at improvements and extensions that would improve the reliability and validity of the experimental process by reducing the impact of the identified random and systematic errors.

justified conclusion/s linked to the research question

The response uses sound reasons and evidence to support a conclusion that directly responds to the research question.

Communication [2]

fluent and concise use of scientific language and representations

The response is easily understood, avoids unnecessary repetition and meets the required length.

Communication [2]

acknowledgment of sources of information through appropriate use of referencing conventions The use of a referencing system fits the purpose of a scientific report.	**Reference List** Birrell, CL, McCook, LJ, Willis, BL, 2005, 'Effects of algal turfs and sediment on coral settlement', *Marine Pollution Bulletin*, vol. 51, pp. 408 - 414 Castro, P and Huber, ME, 2010 'Marine Biology, 8th edn. Retrieved from: file:///C:/Users/tmar/Downloads/cas09341_CH14.pdf Connell, JH, 1978,' Diversity in tropical rain forests and coral reefs', *Science,* vol.199, pp. 302–1310. Costanza, R, de Groot, R, Sutton, P, van der Ploeg, S, Anderson, SJ, Kubiszewski, I, Farber, S, Turner, RK, 2014, 'Changes in the global value of ecosystem services', *Global Environmental Change* vol. 26, pp.152 - 158. Hill, J and Wilkinsion, C, 2004, 'Methods for ecological monitoring of coral reefs' Retrieved from: https://portals.iucn.org/library/efiles/documents/2004-023.pdf Lapoint, BE, Barile, PJ, Littler, MM, Littler, DS, Bedford, BJ, Gasque, C, 2005, 'Macroalgal blooms on southeast Florida coral reefs I. Nutrient stoichiometry of the invasive green alga *Codium isthmocladum* in the wider Caribbean indicates nutrient enrichment', *Harmful algae* vol. 4, pp. 1092 -1105. McCook, LJ, 2001, 'Competition between corals and algal turfs along a gradient of terrestrial influence in the nearshore central Great Barrier Reef', *Coral reefs*, vol. 19, pp. 419 - 425. Moberg, F and Folke, C, 1999, 'Ecological goods and services of coral reef ecosystems', *Ecological Economics* vol. 29, pp. 215 – 233. Roth, MS, 2014, 'The engine of the reef: photobiology of the coral-algal synbiosis', *Front Microbiology*, vol. 5, pp. 422 Webster, AJ, Bartley, R, Armour, JD, Brodie, JE, Thorburn, PJ, 2012, 'Reducing dissolved inorganic nitrogen in surface runoff water from sugarcane production systems', *Marine Pollution Bulletin,* vol. 65, pp. 128 - 135