Marine Education

Student Experiment

Name:

Date:

Year 11 Mandatory Practical

Conduct an investigation to determine factors of population dynamics (e.g. density or distribution) and assess abiotic components of a local ecosystem case study. Emphasis should be placed on assessing the processes and limitations of the chosen technique (e.g. quadrat, transect). When identifying and describing marine species, use field guides and identification keys.

ANSWERS

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

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[1] Queensland Curriculum and Assessment Authority (2018). *Marine Science 2019 v1.2: General Senior Syllabus. QCAA*. Accessed 2019 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.

Mandatory Practical

The Scientific Method

Name:

Date:

1. Observation

The scientific process always starts with an observation. Something is observed about something. Whether that something was the result of a previous study, a political issue, or just your own sense of curiosity, an observation was made. For this investigation, the observation will be something you observe about a *population*. For example, you might observe that some species are present in some places and absent from others (i.e. distribution). Or, you might observe a population has a very large abundance compared to others (i.e. *relative* density).

2. Model

It may or may not be obvious *why* a population is the way that it is. Regardless, it is important to first research as much background information as you can to find out. There will be more than one explanation. Model all explanations (i.e. mind-map or list). Select *one* to test. Keep the model – don't throw it away - because you'll need to either control or measure the remaining items on the list.

3. Aim, Research Question & *null* Hypothesis

Once you have your aim, create one or more research questions. Each question must be very specific. It must include the dependent and independent variable and have a *null* hypothesis to test.

4. Experimental Design

So, what sampling method is most appropriate? The *easy* answer to that question is a sampling method that has been used, tried and tested before! The benefit of standardising the methodology is that your data can be compared to other data! Do your homework, *thoroughly*, for this part of the planning process is very important!!

5. Data Collection

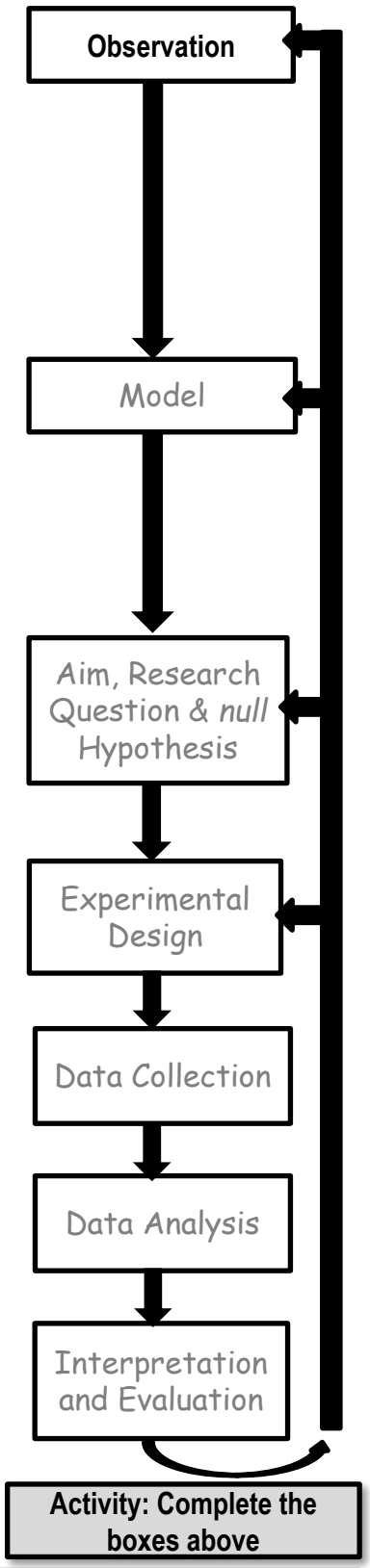
The fun part!

6. Data Analysis

The *Results.* What is the answer to your research question/s? Do you accept or reject the null hypothesis? Could your answer be incorrect?

7. Interpretation and Evaluation

Why did you get those results? What do the results mean? How bullet-proof was your experimental design? How can it be improved? Can you update your model? Any other variables to test (new questions)? Did you come across any new observations to investigate?



Activity: Complete the boxes above

Mandatory Practical

Observation

Name:

Date:

What do you want to know? Research can be categorised into four general types of study[1]:

☐ Baseline Study

Data is collected to define the present state of a biological assemblage (i.e. surveyed for the first time).

☐ Impact Study

Data is collected to determine if an **impact** *changes* a population or assemblage.
Note: some impacts have *negative* effects (i.e. sewage outfalls, dumping of dredging, introduction of exotic species, climate change) whilst others have *positive* effects (i.e. marine parks, catch limits etc.).

☐ Monitoring Study

Data is collected repeatedly to detect any changes from the present state (often follows an impact study).

☐ Patterns and Processes

Data is collected to describe the distribution and abundance patterns of organisms, with the intention of identifying the processes responsible for them.

Activity: Tick one box above to indicate the type of research (& purpose) of your investigation

The Study Site/s… To make an observation, it really helps to *visit* the study site (this can be virtual).

Activity: Describe the study site/s.

Make the Observation… Look at the life that is around you (at the study site/s). What do you see? Make an observation about a **population** – a group of individuals of the same species living in the same place and time. Choose wisely. This is what you will be measuring. This is your **dependent** variable!

Q1. What is the name (*Genus species*) of the population? Ans.

Suggestions: a bio-indicator, habitat forming species, keystone species, herbivore, primary producer, tertiary consumer, commercial species

Q2. What was the observation you made about this population? E.g. Does the population change between two different times, or two different locations, or over a gradient of time or space? **Ans.**

Q3. What is the best way to measure this population? E.g. population density? distribution? **Ans**.

E.g. population size, population density, percentage cover, frequency, etc.

[1] Adapted from: Kingsford, M. and Battershill, C. (1998). *Studying temperate marine environments: A handbook for ecologists*. Canterbury University Press. NZ. p.19

Mandatory Practical

Model

Name:

Date:

Making a Model

Why was the population like that? To find out, you need to make a model. Your model will comprise of a collection of explanations for your observation. Examples of models include a mind-map, a list, a bunch of graphs, an animation, etc. When making your model, include ALL plausible explanations for the observation (not just the most obvious explanation, or the one you are most familiar with). This will require lots of reading (*hint:* start your bibliography now – it will save you lots of time later!!!).

Activity: Research the following (and take lots of notes). **Tick the checklist box when complete.**

- ❑ **Biology:** adaptations for survival (e.g. structural, functional, behavioural), reproductive strategies
- ❑ **Ecology:** the **biotic** and **abiotic** components of its environment (and the interactions within and between them)

Activity: In the space below, create a model to include all explanations for your observation.

Pick ONE to investigate!

Your model will be far too complex, with too many explanations to investigate all at once on your own. Therefore, pick just one explanation from the model (above) to investigate further. Pick the one that makes the most sense (and other scholars think so too) and, if possible, is easy to measure (e.g. abiotic). This is your **independent** variable!

Importantly, all other variables must be controlled (CV). If they can't be controlled, they must be measured (MV), so their influence can be considered in the outcome of the study.

Q1. Which explanation did you pick? E.g. What changed that (you think) made the population change? Was it time, location, other species, protection level, a pollutant? Pick only ONE! **Ans.**

Q2. How are you going to measure this change to the independent variable, to measure its effect on the population? E.g. group 1 (effect) vs group 2 (no effect). **Ans.**

Mandatory Practical

Aim, Research Question & *null* Hypothesis

Name:

Date:

The aim of this investigation is to measure the effect of …….on……..

The aim of your investigation will be to measure the effect of the independent variable (Q1 on page 63) *on* the observation that you made about a population (Q1 & 3 on page 62).

Activity: Complete this sentence: *The aim of this investigation is to …..*

The Research Question

It is very important to create a research question that can be answered using the data that you collect!!!!! One way to ensure you can do this, is to word the research question in one of two ways….

Is there a difference in ….. between ……. & …….?

Is there a (linear) relationship between ……. & ……..?

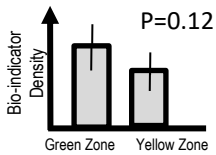
If you don't word it like this, you won't be able to (statistically) answer your research question! For example,

Q. Is there a difference in _____ **between** _____ **&** _____ **?**

The dependent variable (Q1&3 page 62)

Two groups to compare (Q2 page 63)

For example,
Is there a difference in the *density of Morula sp.* between the *high tide zone* and *low tide zone*?
Is there a difference in *percentage cover* of *Rhizophora stylosa* between Location A and Location B?
Is there a difference in the *density of a bio-indicator species* between a *protected* and *unprotected* zone?
Is there a difference in the *population size of an endangered species* between *last year* and *this year*?



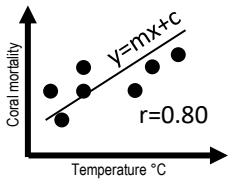
Or, you can word it like this….

Q. Is there a (linear) relationship between _____ **&** _____ **?**

Must be CONTINUOUS data (& measured as a pair)

For example,
Is there a (linear) relationship between *abundance* of *Grapsidae crabs and abundance of pnematophores*?
Is there a (linear) relationship between *abundance of species x* and *body size*?
Is there a (linear) relationship between *coral mortality* and *temperature*?

For this type of question, once you have measured both pairs of continuous data, draw up a scatter graph (with one dataset on the x-axis and the other dataset on the y-axis). Plot the data and draw a (straight) line of best fit (y=mx+c). If plots are close to the line, a 'linear' relationship exists, which is quantified by Pearson's Correlation Coefficient or 'r'. The closer r is to 1, the closer the plots are to the line and the stronger the relationship.



Activity: Create one or more research questions using the formatting described above

***Note:* the '*null*' hypothesis is a *statistical* term that *always* states there is NO difference (or NO relationship) between this and that. Your results will either accept or reject the null hypothesis.**

Sampling Techniques and Equipment

Your choice of sampling technique and equipment depends on a number of factors: the *environment* that you are sampling, the *scale* of the sample question, the *size* and *mobility* of the organisms, and *time* and *budget* constraints. *Note:* if you standardise the methodology by replicating what others have done in the past, you can compare data! Below is a comprehensive list of sampling techniques and equipment.

Subtidal Hard Substrata (e.g. reefs)

- Satellite Images and Aerial Photography
- Echo sounding
- Side-scan sonar (swath mapping)
- Remote sensing and GIS
- Manta Tow
- Free-swimming Observer
- Underwater Video (remotely or diver controlled)
- Spot-checks
- Quadrats and Transects
- Photography
- Sample Removal (plastic and mesh bags)
- Marking and Tagging
- Core Sampling
- Benthic Grabs
- Airlifts (i.e. suction airlift)

Intertidal Hard Substrata (e.g. rocky shores)

- Quadrats & Transects
- Remote sensing and GIS
- Photography
- Sample removal
- Marking and Tagging
- Exclusion Cages

Soft Sediments (e.g. beach)

Box corer and sieve with various mesh sizes for:

- Megafauna >200mm
- Macrofauna 0.5mm-200mm
- Meiofauna 0.063mm-0.5mm
- Microfauna <0.063mm
- Sediment Analyses
- Echo sounding
- Remote sensing

Intertidal Estuarine Vegetation (i.e. mangroves)

- Aerial photography, remote sensing and GIS
- Quadrats and Transects

Fish Communities

- Hand lines and set lines
- Traps
- Belt transects
- Stationary visual technique
- Video methods (i.e. BRUV)
- Tagging
- Gill nets
- Fish traps
- Seine (drag) nets
- Trawls
- Electrofishing
- Fish poisoning
- Visual consensus
- Pot-net traps
- Drop net traps and throw traps
- Cast nets

Plankton

- Plankton nets and Plankton Tows
- Continuous plankton recorder (i.e. towed over transects 400nmiles at speeds up to 20knots)
- Remote sensing
- Depth stratification in planktonic communities
- Water pumps
- Water bottles (open and close at depth)
- Cod-ends and collecting buckets
- Purse-seine nets
- Plankton traps (demersal and light)
- Optical plankton counters

Addressing limitations

Every sampling technique, every piece of equipment and every methodology has certain limitations. If you ***fail*** to identify these limitations, the **validity** of your experiment will be compromised. E.g. you will accept the null hypothesis when it should have been rejected, or vice versa.

For example, pictured left is a crown of thorns starfish (note the spikes). It is tucked in behind the branches of a staghorn coral. Its hidden position may obscure it from view. As a result, the 2D (as opposed to 3D) nature of the quadrat is a limitation of the quadrat. Another limitation is when mobile animals 'flee from the scene'. Or, if the quadrat is too large or too small (or out of focus) for the size and scale of what is being measured.

Activity: Download and peruse the following publication:

Hill J. & Wilkinson, C. (2004). *Methods for Ecological Monitoring of Coral Reefs: A resource for Managers: Version 1.* AIMS. Townsville. QLD. ISBN: 0 642 322 376

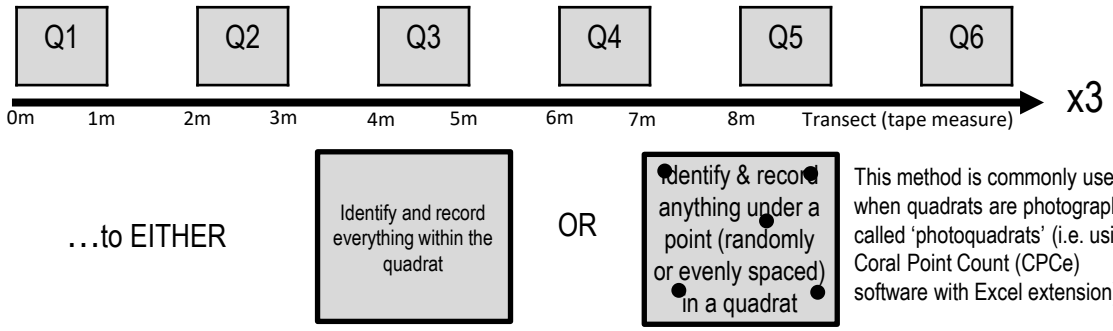
Quadrats and Transects

Quadrats and transects are common tools of the trade in marine science research. Below is a brief overview of the Quadrat-transect method, the Point Intercept Method and the Line Intercept Method[1].

Quadrat-transect method

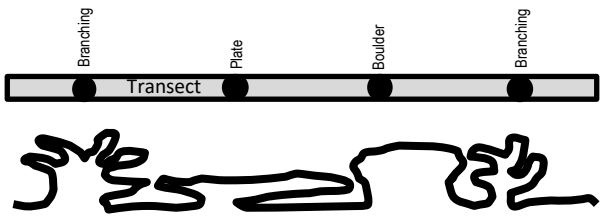
Quadrats (i.e. squares) are *randomly* placed along a transect, ***or,*** *evenly* spaced along a transect.

For example, a 1mx1m square quadrat is placed every 2m along a transect (tape measure)……



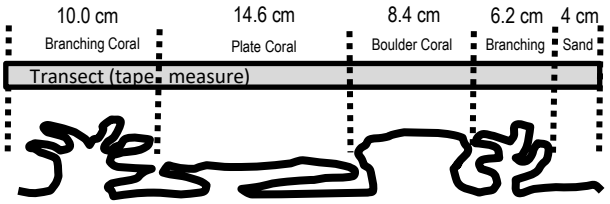
Point Intercept Method ●

Identify & record anything under a point along a transect (points are randomly *or* equally spaced)



Line Intercept Method

Identify and record anything under a length of transect (the transect is a tape measure)



Replicates and Precision

Marine environments can be highly variable (i.e. different) in both space and time. To collect enough information that is representative of the entire area of interest, you need to take more than one sample at a survey site. Additional samples are called **replicates**[1]. The number of replicates that you choose to include in your experimental design depends on the level of **precision** (and reliability) that you desire. Precision is the degree to which several measurements (replicates) provide answers very close to each other.

Because marine environments, such as coral reefs, are highly variable, replicates are rarely *exactly* the same. But if you have *enough* of them, they can come close. If you don't have enough replicates, the level of precision, and the **reliability** of the experiment, will be low (you will know this because your standard deviation will be high). As a result, you will not be able to detect any significant difference between two populations (if there is one) and accurately answer your research question. If you think this has happened to you, recommend more replicates and consider a **stratified,** or **nested sampling design** for next time.

[1] Adapted from: Hill J. & Wilkinson, C. (2004). *Methods for Ecological Monitoring of Coral Reefs: A resource for Managers: Version 1.* AIMS. Townsville. QLD. ISBN: 0 642 322 376

Quadrat and Transect Data

Either identify species as you go along, writing their scientific names on the data sheet *in the field* (see below left) OR set up categories of what to measure, *prior* to sampling in the field (see below right).

Quadrat-transect Method - identifying and recording everything in the quadrat

SCIENTIFIC NAME	Tally of *individuals* OR percentage cover of *modular* organisms (Q stands for Quadrat)			
	Q1	Q2	Q3	Q4

etc.

OR

Quadrat-transect Method - identifying and recording everything in the quadrat

CATEGORY	Tally of *individuals* OR percentage cover of *modular* organisms (Q stands for Quadrat)			
	Q1	Q2	Q3	Q4
HARD CORAL				
SOFT CORAL				
TURF ALGAE				

etc.

Quadrat-transect Method - identifying and recording anything under a randomly placed point in the quadrat

SCIENTIFIC NAME	TALLY of POINTS (i.e. 50/Quadrat)			
	Q1	Q2	Q3	Q4

etc.

OR

Quadrat-transect Method - identifying and recording anything under a randomly placed point in the quadrat

CATEGORY	TALLY of POINTS (i.e. 50/Quadrat)			
	Q1	Q2	Q3	Q4
HARD CORAL				
SOFT CORAL				
TURF ALGAE				
DEAD CORAL				

etc.

Point-Intercept Method

POINT	SCIENTIFIC NAME
1	
2	
3	
4	
5	
6	

etc.

OR

Point-Intercept Method

POINT	CATEGORY
1	
2	
3	
4	
5	
6	

etc.

Substrate Code
Adapted from Reef Watch methods

HC Hard Coral
RB Rubble
OT Other
SC Soft Coral
SD Sand
RC Rock
SI Silt/Clay
NIA Nutrient Indicator Algae
RKC Recently Killed Coral

Line-Intercept Method

LINE INTERCEPT (cm)		SCIENTIFIC NAME
START	FINISH	

etc.

OR

Line-Intercept Method

LINE INTERCEPT (cm)		CATEGORY
START	FINISH	

etc.

Substrate Code

HC
RB
OT
SC
SD
RC
SI
NIA
RKC

Mandatory Practical

Data Collection - Safety

Name:

Date:

Activity: Complete the tables below

Hazard	Likelihood it occurs 1 (unlikely) – 5 (highly likely)						Severity of injury (worst case scenario) 1 (minor) – 5 (major)					Action/s to reduce the risk
	1	2	3	4	5		1	2	3	4	5	
On a BOAT												
Seasickness	x	x	x	x			x	x				Seasickness tablets
Dehydration												Bring extra water, drink often
Sunburn												Sunscreen, wear protective clothing
Equipment malfunction												Maintain, check and safely stow equipment, bring spares
Collision												Follow COLREGS and IALA, maintain lookout
Loss of a passenger												Buddy system, log book, roll call, head count
IN the WATER												
Ruptured eardrum												Equalisation of ears every metre going down
Swept away by current												Listen to safety brief and follow instructions
Separation from others												Look up and around you at least every minute
Lookout can't see you												Take a whistle and safety sausage with you in the water
Hyperthermia												Wear the correct wetsuit, bring warm change of clothes
Mask strap breaks												Don't stray far from boat. Bring spares
Lack of floatation												Take floatation device (i.e. noodle)
Ethical Standard Breach												Find out the rules when working with animals
Irukandji Sting												Avoid (Oct-April). Wear stinger suit.

Dangerous Marine Creature	Signs/Symptoms	First Aid
Irukandji – related to box jellyfish (*note:* average size is 2cm).	Initial sting is painless. 20min later, severe lower back pain followed by nervous system shut down	Evacuate asap to nearest medical facility. Reassure patient and be ready to conduct CPR. Administer O_2.
Box Jellyfish	Very painful whip marks → Heart attack	DRABC. Vinegar to remove tentacles.
Blue bottle	Painful whip marks → Lymph node pain	Remove tentacles. ICE to soothe pain.
Stinging Hydroid (e.g. fire coral)	Painful, itchy weals	Flush with Vinegar. ICE to soothe pain.
Sea urchin or Crown of Thorns (spine)	Pain, redness and swelling around wound	Bathe in vinegar before removing.
Stone fish (spine)	Extreme pain at the site of the wound	DRABC. HOT water
Sting ray (barb)	Extreme pain at the site of the wound	DRABC. HOT water
Animal Bite (moray eel, shark etc.)	Excessive bleeding	DRABC. Stop bleeding. Treat for shock.
Textile Cone Shell	Puncture → numbness → breathing failure	DRABC. Immediate evacuation.
Blue-ringed Octopus (bite)	Bite is often not felt → paralysis	DRABC. Immediate evacuation.

Mandatory Practical

Data Analysis

Name:

Date:

Activity: Follow the flow chart to analyse your data and answer your research question!

Q. Is there a difference in [Dependent Variable] **between** [Population (Group) 1] **&** [Population (Group) 2] **?**

Start here

Q1. Is this the wording of your research question?

No → Go to Next Page

Yes →

Q2. Is the dependent variable **abundance**? Yes →

No →

Q3. Is the dependent variable **population size** (N)?

No →

Yes →

Population Size= $\bar{x}$ x total *area* of population / area of one quadrat
(Quadrat Method)

where:
N = Total Population Size
$\bar{x}$ = **sample mean =** TOTAL count of individuals / number of quadrats

Q4. Is the dependent variable **population density**?

No →

Yes →

Density = Population size (see above) / Area

Q5. Is the dependent variable **percentage cover**?

No → See your teacher

Yes →

Q6. Did you use sample *points* in your methods?

No →

Yes →

Percentage Cover = $\frac{\text{Total number of sample points occupied by a species}}{\text{Total points sampled}}$ x100

Q7. Did you use the Line Intercept Method?

No →

Yes →

Percentage Cover = $\frac{\text{Total length of transect occupied by a species}}{\text{Total transect length}}$ x100

Q8. Did you use a quadrat in your methods?

No → See your teacher

Yes →

Percentage Cover = $\frac{\text{Total \% cover for all quadrats}}{\text{Total number of quadrats}}$ x100

Calculate the mean, standard deviation, standard error & confidence interval of each population (group).

Conduct a t-test or use error bars to statistically answer your research question.

See pages 52-54 for instructions

Mandatory Practical

Data Analysis

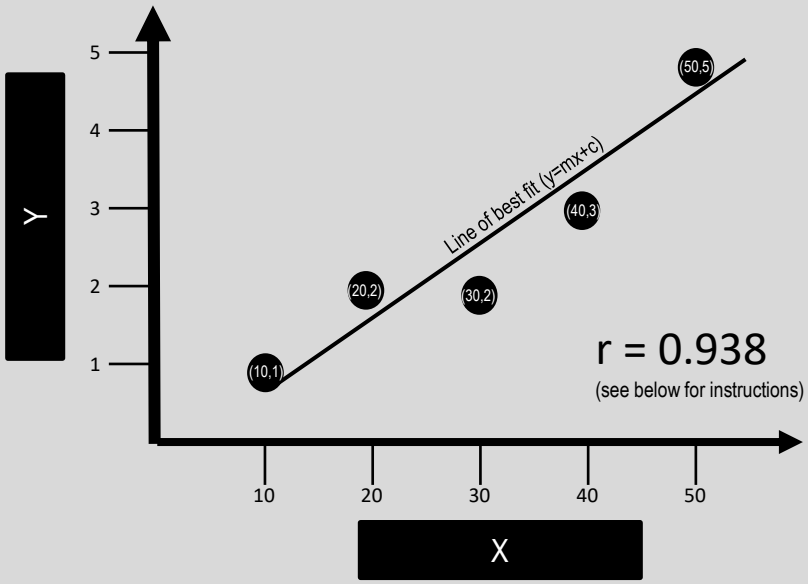
Name:

Date:

Q. Is there a (linear) relationship between Dependent Variable **&** _____ **?**

Y X

Condense your data into two columns, x and y.



For example….

	X	Y
(10,1)	10	1
(20,2)	20	2
(30,2)	30	2
(40,3)	40	3
(50,5)	50	5

Pearson's Correlation (r)

…is a measure of the strength of the *linear* relationship between two variables, x and y.

The value r =1 indicates the strongest possible positive relationship between x and y (i.e. as one increases the other increases).
The value r = - 1 indicates the strongest possible negative relationship between x and y (as one increases, the other decreases).
The value r = 0 ± 0.5 indicates no ***linear*** relationship between x and y. *Note:* this does not rule out any strong relationship between x and y. There could still be a strong relationship, but one that is not linear.

How to calculate r manually

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$

where: n= sample size (i.e. 5) and; ∑ is the SUM of….(i.e. total).

	X	Y	XY	X^2	Y^2
	10	1	10	100	1
	20	2	40	400	4
	30	2	60	900	4
	40	3	120	1600	9
	50	5	250	2500	25
Total	∑x	∑y	∑xy	$\sum x^2$	$\sum y^2$
	150	13	480	5500	43

How to calculate r in EXCEL:

Simply click on an empty cell and type **=CORREL(X , Y)**
where: X is the column containing all the data for the x-axis &
Y is the column containing all the data for the y-axis.

	A	B	C
1	X	Y	= CORREL(A2:A6,B2:B6)
2	10	1	
3	20	2	
4	30	2	
5	40	3	
6	50	5	

Mandatory Practical

Interpretation and Evaluation

Name:

Date:

Taking control

In the lab, when conducting an experiment, conditions are strictly controlled. In the field, we aim to control as many variables possible (i.e. date, time, tide, etc.). However, given that it is outside, there are many variables that *can not* be controlled. These are called '*measured variables'.* They're called *measured variables* because they need to be measured. Why? Because they can influence the result.

Activity: Below, **list the *measured variables*** from your original model on page 63 (those you couldn't control….and hopefully measured!**). Rank** them from most likely to least likely to influence the result.

Detective work

A researcher must always consider the probability that the result is incorrect – either the experiment failed to pick up a difference when there was one, or the experiment found a difference that didn't exist. The **data analysis** (incl. *measured variables*) and **experimental design** must therefore be critically analysed.

	Question	Answer
Data Analysis	• Did you use the correct statistics test for the wording of the research question? • How close to 0.05 (the cut-off point) was the P value? • If the difference was significant, how close to zero was the P value? • If applicable, how close was r (Pearson's correlation coefficient) to 1.0 or -1.0? • How close to zero were the values for s (standard deviation), SE & CI? (if they were *not* close to zero, you need to examine why your replicates were not the same) • Did you construct a graph to make a visual comparison before reaching a conclusion? • Were any *measured variables* likely to have influenced the result? • Were there any variables that could *not* be controlled, measured?	
Experimental Design	• Could you have picked a better dependent variable (population) to measure? • Could you have changed the independent variable in a different (and more effective) way? • Should you have used qualitative data instead of quantitative data and vice versa? • Did the experimental design take into account the dispersion patterns of the population (i.e. clumped)? • Were there enough replicates? Were the replicates independent of each other, to avoid double counts? • Was there *randomisation* in sampling to avoid bias? • Was the size of the sample unit appropriate for the size of the organism? • Was the choice of sample unit appropriate for the mobility of the organism? • Were the limitations of the sampling technique addressed? • Was the scale of the experimental design suitable for the scale of the research question?	

Q. How *valid* are your results (e.g. answers to *data analysis* questions above) **and WHY? Ans.**

Q. How *reliable* are your results (e.g. answers to *experimental design* questions) **and WHY? Ans.**

Mandatory Practical

Example 1

Name:

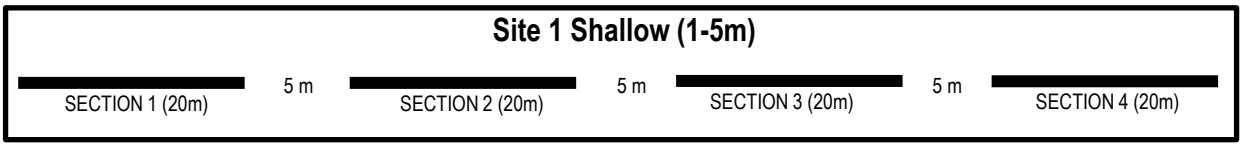
Date:

The aim of this investigation is to measure **the effect of *depth* on *mean percentage hard coral cover.***

Q. Is there a difference in Mean Percentage Hard Coral Cover **between** Site 1 Shallow (1-5m) **&** Site 2 Deep (10-12m) **?**

Reef Check Methodology

Reef Check surveys[1] use the point-intercept method along an 80m transect line (at constant depth) that has been divided into four x 20m sections, each separated by 5m. Divers measure and record the substrate code of benthos under every point at 0.5m along each section of transect to later calculate percentage cover. Transect sites are grouped into Shallow (1-5m) and Deep (10-12m).



Substrate Code

HC hard coral | **RB** rubble | **SC** soft coral | **SD** sand | **RC** rock
NIA nutrient/indicator algae | **OT** other | **SP** sponge | **RKC** recently killed coral | **SI** silt/clay

[1] Adapted from: Hodgson, G., Hill, J., Kiene, W., Maun, L., Mihaly, J., Liebeler, J., Shuman, C. and Torres, R. (2006). *Reef Check Instruction Manual: A Guide to Reef Check Coral Reef Monitoring. 2006 Edition.* Reef Check Foundation, Pacific Palisades, California, USA. Accessed 2018 from: https://www.biosphere-expeditions.org/images/stories/pdfs/2006%20Reef%20Check%20Instruction%20Manual%20with%20covers.pdf

Site 1 Shallow (1-5m) Raw Data

SECTION 1 (S1)			
0	HC	10	RC
0.5	HC	10.5	RC
1.0	NIA	11	RC
1.5	SD	11.5	OT
2.0	SD	12	SC
2.5	HC	12.5	SC
3.0	OT	13	SP
3.5	RC	13.5	SP
4.0	OT	14	HC
4.5	NIA	14.5	HC
5.0	NIA	15	RKC
5.5	NIA	15.5	RKC
6.0	SP	16	RKC
6.5	SP	16.5	RKC
7.0	SI	17	RC
7.5	SI	17.5	HC
8.0	SI	18	SI
8.5	SI	18.5	SI
9.0	SI	19	SI
9.5	SI	19.5	SP

SECTION 2 (S2)			
0	HC	10	HC
0.5	HC	10.5	HC
1.0	HC	11	HC
1.5	SC	11.5	SC
2.0	RC	12	RC
2.5	HC	12.5	HC
3.0	RCK	13	OT
3.5	RCK	13.5	RC
4.0	SD	14	OT
4.5	SD	14.5	OT
5.0	SD	15	SC
5.5	RB	15.5	SC
6.0	RB	16	SP
6.5	RB	16.5	SP
7.0	RB	17	SI
7.5	SI	17.5	SI
8.0	SI	18	SI
8.5	SI	18.5	SI
9.0	SI	19	SI
9.5	SI	19.5	SI

SECTION 3 (S3)			
0	RC	10	HC
0.5	RC	10.5	HC
1.0	RC	11	HC
1.5	OT	11.5	SC
2.0	RKC	12	RKC
2.5	RKC	12.5	RKC
3.0	RKC	13	RKC
3.5	SP	13.5	RC
4.0	HC	14	OT
4.5	RC	14.5	RKC
5.0	RC	15	RC
5.5	SP	15.5	RKC
6.0	RC	16	SP
6.5	RC	16.5	SP
7.0	NIA	17	SO
7.5	SP	17.5	SO
8.0	SI	18	SO
8.5	SI	18.5	SD
9.0	SI	19	SD
9.5	SP	19.5	SI

SECTION 4 (S4)			
0	RC	10	HC
0.5	RC	10.5	HC
1.0	RC	11	HC
1.5	NIA	11.5	SC
2.0	RB	12	RC
2.5	RB	12.5	HC
3.0	SP	13	OT
3.5	NIA	13.5	RC
4.0	NIA	14	OT
4.5	NIA	14.5	OT
5.0	RKC	15	SC
5.5	RC	15.5	NIA
6.0	RKC	16	NIA
6.5	SC	16.5	NIA
7.0	SP	17	SI
7.5	SP	17.5	SI
8.0	SI	18	SI
8.5	SI	18.5	SI
9.0	SI	19	SI
9.5	SP	19.5	SI

Mandatory Practical

Example 1

Name:

Date:

Site 1 Shallow (1-5m) Analysis

Tally how many times Hard Coral (HC) was recorded under a point along each 20m transect section on page 72. For example, HC was found under 6 points along section 1, under eight points along section 2, under four points along section 3, and under four points along section 4 (highlighted on Table 1). Importantly, our dependent variable is *%* HC cover (*not* a tally of the number of HC points). Therefore, we must now calculate the % HC cover using the tally of points that were recorded as HC. Because there were a total 40 points in each section, simply divide each tally of HC by 40. This gives % HC cover as a decimal. To convert from decimal to percentage, simply multiply by 100. For example, 6 out of 40 points (for HC in S1) is the same as 15% cover (6/40)x100=15

Table 1: Tally

Code	Number of points			
	S1	S2	S3	S4
HC	**6**	**8**	**4**	**4**
SC	2	4	1	3
RKC	4	3	8	2
NIA	4	0	1	7
SP	5	2	6	4
RC	5	3	9	6
RB	0	4	0	2
SD	2	3	2	0
SI	9	10	7	9
OT	3	3	2	3
TOTAL	40	40	40	40

Table 2: Percentage Cover

Code	% Cover (__ /40*100)			
	S1	S2	S3	S4
HC	**15**	**20**	**10**	**10**
SC	5	10	2.5	7.5
RKC	10	7.5	20	5
NIA	10	0	2.5	17.5
SP	12.5	5	15	10
RC	12.5	7.5	22.5	15
RB	0	10	0	5
SD	5	7.5	5	0
SI	22.5	25	17.5	22.5
OT	7.5	7.5	5	7.5
TOTAL	100	100	100	100

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Example 1

Name:

Date:

Site 2 Deep (10-12m) Raw Data

SECTION 1			
0	HC	10	SC
0.5	HC	10.5	SC
1.0	HC	11	OT
1.5	HC	11.5	OT
2.0	HC	12	SP
2.5	SC	12.5	SP
3.0	SC	13	SP
3.5	SC	13.5	RC
4.0	SC	14	RC
4.5	HC	14.5	SD
5.0	HC	15	SD
5.5	HC	15.5	SD
6.0	HC	16	RB
6.5	HC	16.5	RB
7.0	SC	17	RB
7.5	SC	17.5	HC
8.0	SC	18	HC
8.5	SC	18.5	HC
9.0	SC	19	HC
9.5	SC	19.5	HC

SECTION 2			
0	SC	10	OT
0.5	SC	10.5	OT
1.0	SC	11	OT
1.5	SC	11.5	OT
2.0	HC	12	SP
2.5	HC	12.5	SP
3.0	HC	13	SP
3.5	HC	13.5	RB
4.0	HC	14	RB
4.5	HC	14.5	HC
5.0	HC	15	HC
5.5	HC	15.5	HC
6.0	HC	16	HC
6.5	RC	16.5	HC
7.0	RC	17	HC
7.5	RC	17.5	HC
8.0	SD	18	SC
8.5	SD	18.5	SC
9.0	SD	19	SC
9.5	SD	19.5	SC

SECTION 3			
0	SC	10	HC
0.5	SC	10.5	HC
1.0	SC	11	HC
1.5	SC	11.5	HC
2.0	HC	12	HC
2.5	HC	12.5	HC
3.0	HC	13	HC
3.5	HC	13.5	HC
4.0	SP	14	HC
4.5	SP	14.5	HC
5.0	SP	15	RB
5.5	SP	15.5	RB
6.0	NIA	16	RB
6.5	OT	16.5	RB
7.0	SD	17	RC
7.5	SD	17.5	RC
8.0	SD	18	RC
8.5	OT	18.5	NIA
9.0	OT	19	SP
9.5	OT	19.5	SP

SECTION 4			
0	HC	10	SC
0.5	HC	10.5	SC
1.0	HC	11	SC
1.5	HC	11.5	OT
2.0	HC	12	OT
2.5	HC	12.5	OT
3.0	HC	13	OT
3.5	HC	13.5	RB
4.0	HC	14	RB
4.5	HC	14.5	NIA
5.0	HC	15	NIA
5.5	HC	15.5	NIA
6.0	HC	16	SP
6.5	HC	16.5	SP
7.0	HC	17	SP
7.5	HC	17.5	SP
8.0	SC	18	SD
8.5	SC	18.5	SD
9.0	SC	19	SD
9.5	SC	19.5	NIA

Table 1: TOTAL count

Substrate Type	Number of points			
	S1	S2	S3	S4
HC	15	16	14	16
SC	12	8	4	7
RKC	0	0	0	0
NIA	0	0	2	4
SP	3	3	6	4
RC	2	3	3	0
RB	3	2	4	2
SD	3	4	3	3
SI	0	0	0	0
OT	2	4	4	4
TOTAL	40	40	40	40

Table 2: TOTAL % Cover

Substrate Type	% Cover (__ /40*100)			
	S1	S2	S3	S4
HC	37.5	40	35	40
SC	30	20	10	17.5
RKC	0	0	0	0
NIA	0	0	5	10
SP	7.5	7.5	15	10
RC	5	7.5	7.5	0
RB	7.5	5	10	5
SD	7.5	10	7.5	7.5
SI	0	0	0	0
OT	5	10	10	10
TOTAL	100	100	100	100

Analysis

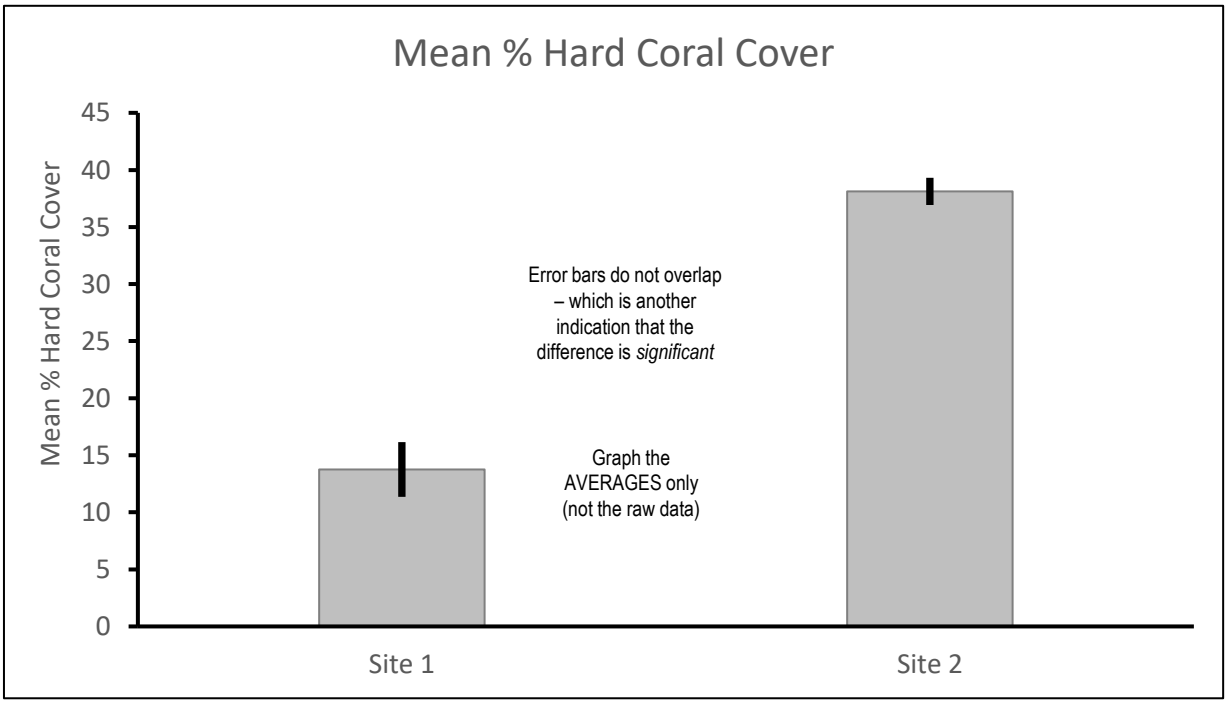
Because there are 4 repeats, the next step is to calculate the **MEAN** % hard coral cover for all 4 repeats (using data from Table 2). E.g. Site 1 is (15+20+10+10)/4 = 13.75%. Site 2 is (37.5+40+35+40)/4 = 38.125% Table 3 shows you how to make the same calculations in EXCEL using the formulas for average as well as standard deviation, standard error and confidence interval (that you'll need to add error bars to your graph).

Table 3: Analysis of Data for % Hard Coral (HC) Cover for Site 1 Shallow (1-5m) and Site 2 Deep (10-12m)

Site	Mean =AVERAGE( )		Standard Deviation (s) =STDEV( )		Standard Error (SE) =STDEV( )/SQRT(4)		Confidence Interval (CI) =CONFIDENCE.T(0.05,(s),4)	
1	HC	13.79	HC	4.79	HC	2.39	HC	7.62
2	HC	38.125	HC	2.39	HC	1.20	HC	3.81

Statistics

So far we know that the mean % HC cover for Site 1 was not the same as the mean % HC cover for Site 2. Site 1 has less % HC cover than Site 2. BUT, is the difference significant? To find out, we did a t-test and got a P value. The P value was 0.0000984. Therefore, the difference in % HC cover between Site 1 and Site 2 is indeed *significant.* Hence, the null hypothesis (stating there was no difference) was rejected. When the P value is less than 0.05 the difference is significant. *Note:* the term significant means a stat test was used.



Evidence that the difference is significant (and the null hypothesis is rejected) include: a significant difference in the height of the columns; the error bars do NOT overlap; and the P value is <0.05 (and close to zero). *However*, the t-test only had 4 data points per site. More would make the results more reliable. *Note:* The error bars were drawn using Standard Error (SE). The SE for Site 1 (shallow) was 2.39 (HC). Whereby the top of the error bar is the mean (13.75) plus 2.39, whilst the bottom of the error bar is the mean (13.75) minus 2.39. The SE and error bar for Site 2 was smaller (less error) than for Site 1.

Mandatory Practical

Example 2

Name:

Date:

The aim of this investigation is to measure the effect of ***distance from high tide*** *on* ***ghost crab distribution***

Juvenile ghost crabs have small, shallow burrows. Whilst *mature* ghost crabs have large, deep burrows. Ghost crabs are sensitive to human disturbance (i.e. 4WD). Thus, ghost crabs are used as bio-indicators[1].

Q. Is there a (linear) relationship between diameter of the entrance to the ghost crab burrow in mm. (Y) **&** distance between burrow and high tide line in cm. (X) **?**

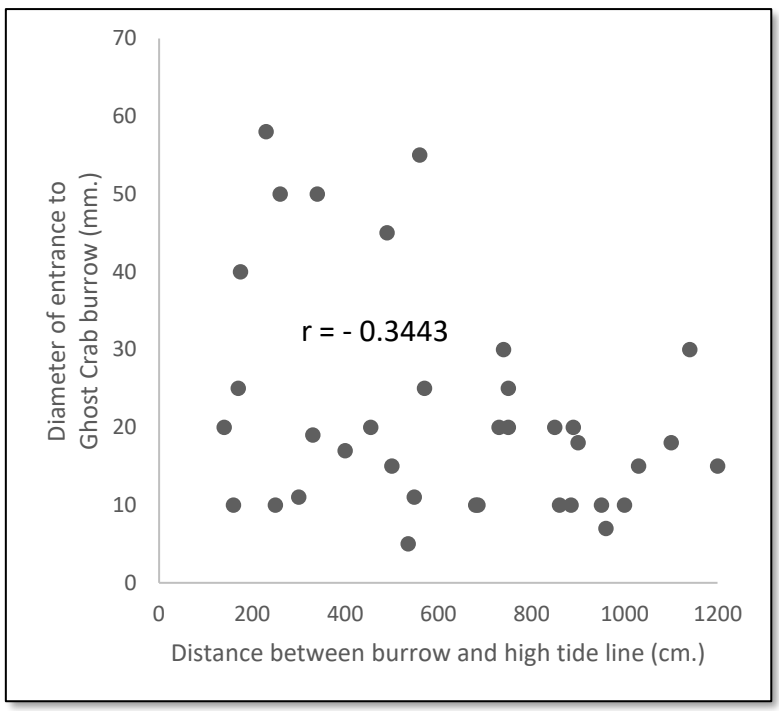
Method: The high tide line was identified and drawn as a line in the sand. Once a ghost crab burrow was located, the diameter of the entrance to the burrow was measured with a ruler (Y), and the distance between the burrow and the high tide line was measured with a tape measure (X). The data was plotted on a scatter graph and Pearson's correlation coefficient was calculated on EXCEL.

RAW DATA
in EXCEL
(36 burrows in total)

	A	B	C
1	X	Y	
2	175	40	
3	140	20	
4	170	25	
5	250	10	
6	340	50	
7	300	11	
8	160	10	
9	400	17	
10	260	50	
11	230	58	
12	490	45	
13	455	20	
14	330	19	
15	535	5	
16	548	11	
17	500	15	
18	560	55	
19	570	25	
20	680	10	
21	685	10	
22	730	20	
23	750	20	
24	740	30	
25	750	25	
26	850	20	
27	860	10	
28	900	18	
29	890	20	
30	885	10	
31	950	10	
32	960	7	
33	1000	10	
34	1030	15	
35	1100	18	
36	1140	30	
37	1200	15	
38	r =	-0.3443	
39	=CORREL(A2:A37,B2:B37)		

Remember the comma!

ANALYSIS: scatter graph on EXCEL
& calculation of Pearson's correlation coefficient (r)



RESULTS

For there to be a relationship between X and Y, the value for 'r ' needs to be between 0.5 and 1.0 or between -0.5 and -1.0 …which it isn't.

Therefore,
there is no relationship between the size of the burrow and the distance from the high tide line. The null hypothesis is accepted (r = - 0.3443).
(*Note*: the 'null' hypothesis is a statistical term that always states there is NO relationship (or difference) between this and that).

Note: if a relationship did exist, there would be a straight line of best fit drawn between all the dots.

Evaluation: The reliability and validity of this experiment is questionable. There were no transects or quadrats, no replicates (in space or time), no consistency when taking measurements, no randomisation in burrow selection (leading to bias), burrows had been disturbed by trampling, the high tide line had suffered erosion, and no other variables were measured, nor controlled.

[1] Schlacher, T. A. & Lucrezi, S. (2010). Compression of home ranges in ghost crabs on sandy beaches impacted by vehicle traffic. *Mar Biol. 157:2467-2474. DOI: 10.1007/s00227-010-1511-8*