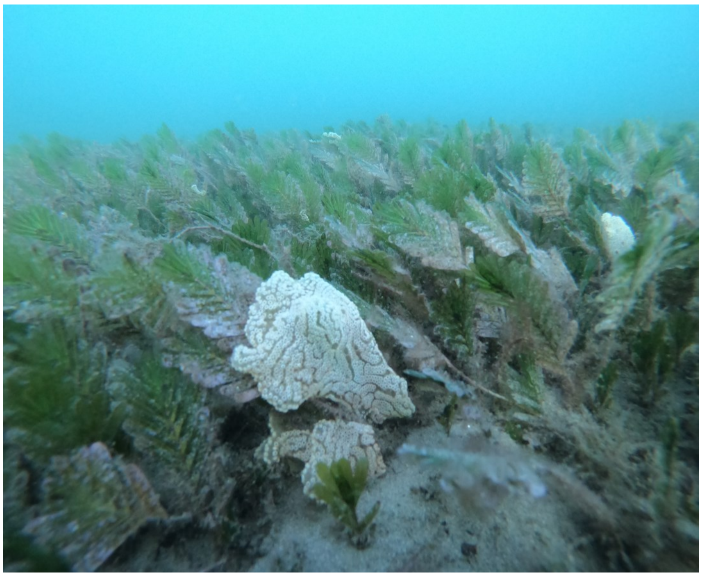
The Changing Ocean Program

Edition 1.0



Teacher's Handbook...

...a resource for the successful completion of the Changing Ocean Program

Implications for our ocean's future

LIVE THE LEARNING
JACOBS WELL ENVIRONMENTAL EDUCATION CENTRE

Contents

Introduction

In Australia the development of the new Queensland Curriculum Assessment Authority syllabus for Biology, released in 2019, has provided great scope and opportunity for teachers and students to get to grips with some effective science. None more so than unit 3 of the Biology syllabus; **Biodiversity and the interconnectedness of life**.

Topic 1: Describing biodiversity

A. Biodiversity

In the **subject matter** of this topic students are asked to perform the following tasks that are relevant to the

1. recognise that biodiversity includes the diversity of species and ecosystems

2. determine diversity of species using measures such as species richness, evenness (relative species abundance), percentage cover, percentage frequency and Simpson's diversity index

3. use species diversity indices, species interactions (predation, competition, symbiosis, disease) and abiotic factors (climate, substrate, size/depth of area) to compare ecosystems across spatial and temporal scales

4. explain how environmental factors limit the distribution and abundance of species in an ecosystem.

Students are also required to complete a **mandatory practical** which determines species diversity of a group of organisms based on a given index.

In the **guidance** recommendations of the QCAA, students can perform the following tasks:

• Use local context throughout the unit to develop the content objectives.

• Diversity indices and measurements should be supported through fieldwork and based on classification. Measures of biodiversity, i.e. species richness (S) and Simpson's diversity index (D) should be used where applicable.

• **Formula:** The formula used to quantify biodiversity of a habitat is Simpson's diversity index (SDI), shown as:

$$SDI = 1 - \left(\frac{\sum n(n-1)}{N(N-1)}\right)$$

$where:$

$N = total\ number\ of\ organisms\ of\ all\ species$

$n = number\ of\ organisms\ of\ one\ species$

• **Manipulative skill:** Use appropriate technology, such as data loggers, chemical tests, turbidity tubes and other equipment to measure factors.

• **Suggested practical:** Measure abiotic factors in the classroom using field samples (e.g. pH, nitrogen nutrients, salinity, carbonates, turbidity).

• **Suggested practical:** Measure abiotic factors in the field (e.g. dissolved oxygen, light, temperature, wind speed, infiltration rate).

Changing Ocean Program:

B. Classification processes

1. Use the process of stratified sampling to collect and analyse primary biotic and abiotic field data to classify an ecosystem.

In the **subject matter** of this topic students are asked to perform the following tasks that are relevant to the Changing Ocean Program:

In the **guidance** recommendations of the QCAA students can fulfil the following tasks during the completion of

• Classification of ecosystems could be based on the Holdridge life zone classification scheme, Specht's classification system, ANAE classification system or **EUNIS habitat classification system**.

Topic 2: Ecosystem dynamics

A. Functioning ecosystems

In the **subject matter** of this topic students are asked to perform the following tasks that are relevant to the Changing Ocean Program:

1. Sequence and explain the transfer and transformation of solar energy into biomass as it flows through biotic components of an ecosystem, including

- converting light to chemical energy
- producing biomass and interacting with components of the carbon cycle

2. Describe the transfer and transformation of matter as it cycles through ecosystems (water, carbon and nitrogen)

3. Define ecological niche in terms of habitat, feeding relationships and interactions with other species

4. Understand the competitive exclusion principle

In the **guidance** recommendations of the QCAA students can fulfil the following tasks during the completion of the Changing Ocean Program:

• Fieldwork should be used to develop scientific skills and collect data, as well as to develop student understanding of concepts, especially abiotic–biotic relationships and biotic–biotic relationships.

B. Population ecology

In the **subject matter** of this topic students are asked to perform the following tasks that are relevant to the Changing Ocean Program:

1. Define the term carrying capacity

2. Explain why the carrying capacity of a population is determined by limiting factors (biotic and abiotic)

3. Discuss the effect of changes within population-limiting factors on the carrying capacity of the ecosystem.

In the **guidance** recommendations of the QCAA students can fulfil the following tasks during the completion of the Changing Ocean Program:

• Limiting factors of population growth should include

- biotic factors — competition for resources, predation and disease
- abiotic factors — space, availability of nutrients, pollution, natural disasters, extreme climatic events (drought, cyclones, global temperature change).

• Suggested practical: Conduct an abundance and distribution study, including abiotic and biotic factors.

C. Changing ecosystems

In the **subject matter** of this topic students are asked to perform the following tasks that are relevant to the Changing Ocean Program:

1. Analyse ecological data to predict temporal and spatial successional changes

2. Predict the impact of human activity on the reduction of biodiversity and on the magnitude, duration and speed of ecosystem change.

3. Mandatory practical: Select and appraise an ecological surveying technique

Assessment:

Summative internal Assessment 2 (IA2): Student Experiment

Using the primary abiotic and biotic data obtained from the determination of species diversity practical, students will hypothesise and investigate relationships between a nominated biotic factor and the abiotic factors that impact the organism.

Autonomous Reef Monitoring Structures (ARMS)

The Changing Ocean Program uses autonomous reef monitoring structures as settlement plates for the collection of settling planktonic organisms.

The original ARMS were developed through a collaboration between the National Oceanic and Atmospheric Administration of the United States of America and the Smithsonian Institute. They were used for part of the Census of Marine Life (CoML) which was started in the year 2000 and ran for ten years. During this time scientists took on the mammoth task of trying to discover and identify as many marine organisms as they could find. The ARMS themselves were used to investigate the distribution and abundance of small organisms that live amongst the three dimensional structures of coral reef systems. The ARMS units that are used in the Changing Ocean Program are composed of six horizontal plates that are secured to a weighted base plate. The structures are deployed for a period of seven weeks in the marine environment. During this period a variety of planktonic organisms settle and grow on the plates. The ARMS deployed on the Gold Coast of Queensland Australia are being used to analyse the settlement of planktonic organisms found in ocean waters entering the Gold Coast Broadwater system.

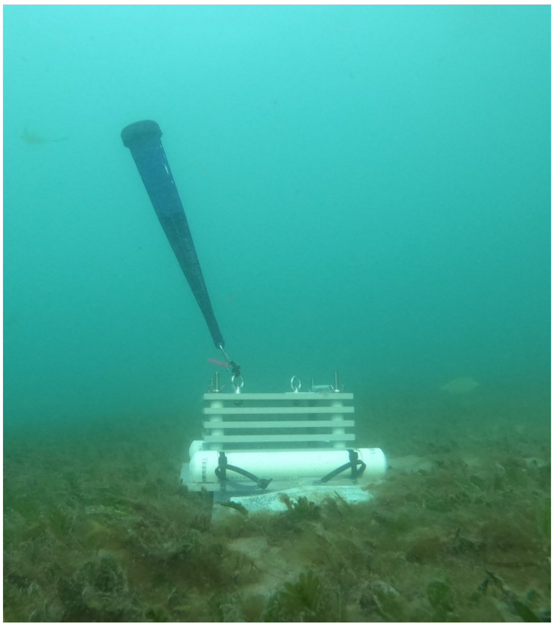


Fig.1. ARMS deployed in seagrass meadow, Queensland Australia (Harrison 2019)

Two ARMS units are deployed for the seven week period of the Changing Ocean Program. One unit being submerged at the mouth of the Gold Coast Seaway in approximately five metres of water on a seagrass meadow (**see Fig. 2**). Whilst the other unit is submerged in approximately five metres of water further North in the Gold Coast's Broadwater system on a seagrass meadow within the confines of the Couran Cove marina (**see Fig. 3**).

These units are placed within 6.5 kilometres of each other (**see Fig.4**) and are therefore exposed to the same flooding ocean water that is carrying the same planktonic organisms. If all other abiotic variables remain constant we could suggest that the settling sessile planktonic communities will be the same at both sites. But are they?

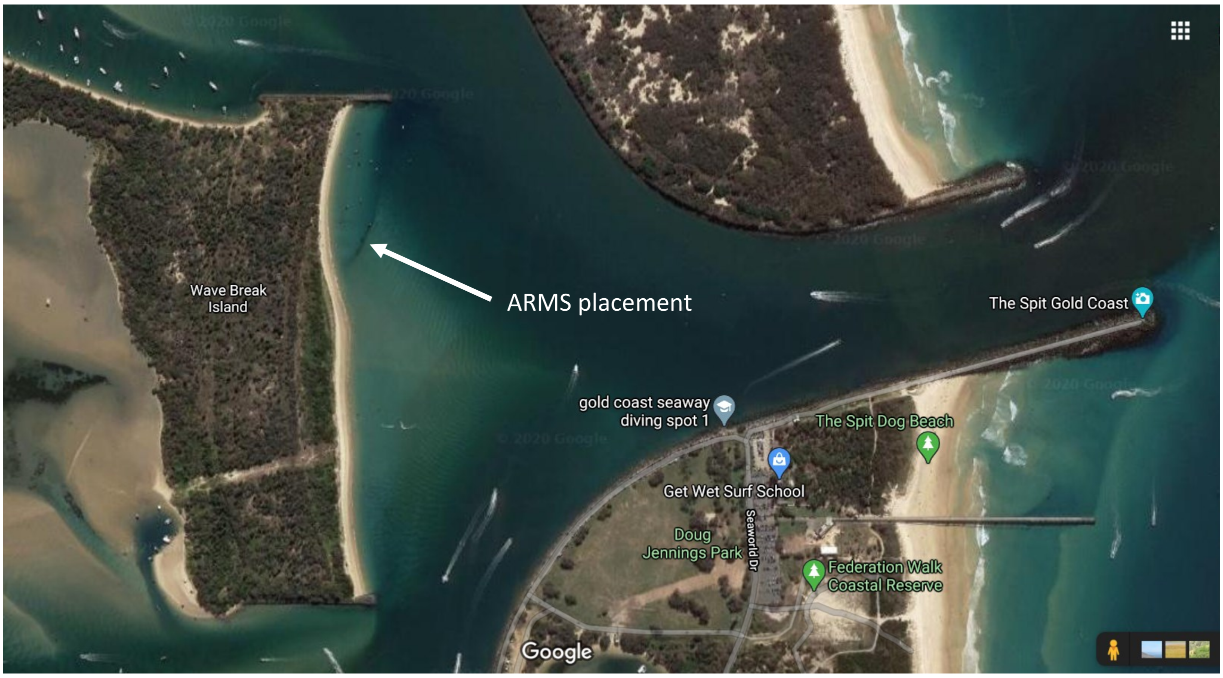


Fig.2. Map displaying placement of ARMS at Wavebreak Island, southeast Queensland, Australia. (Google)

(n.b. dark shadow representing seagrass meadow)

Autonomous Reef Monitoring Structures (ARMS) Deployment Sites

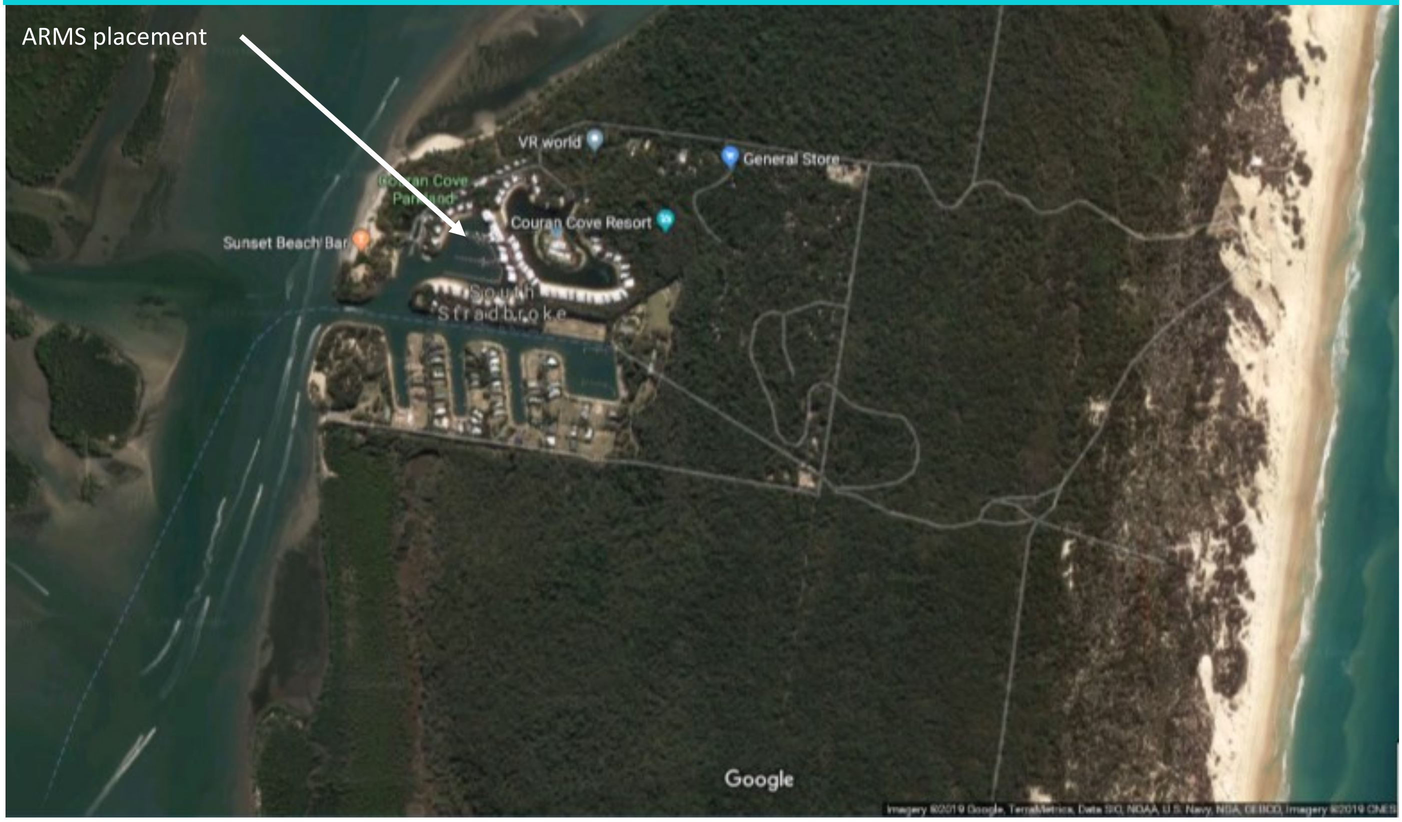


Fig. 3. Map displaying placement of ARMS at Couran Cove Marina, South Stradbroke Island, southeast Queensland, Australia. (Google)

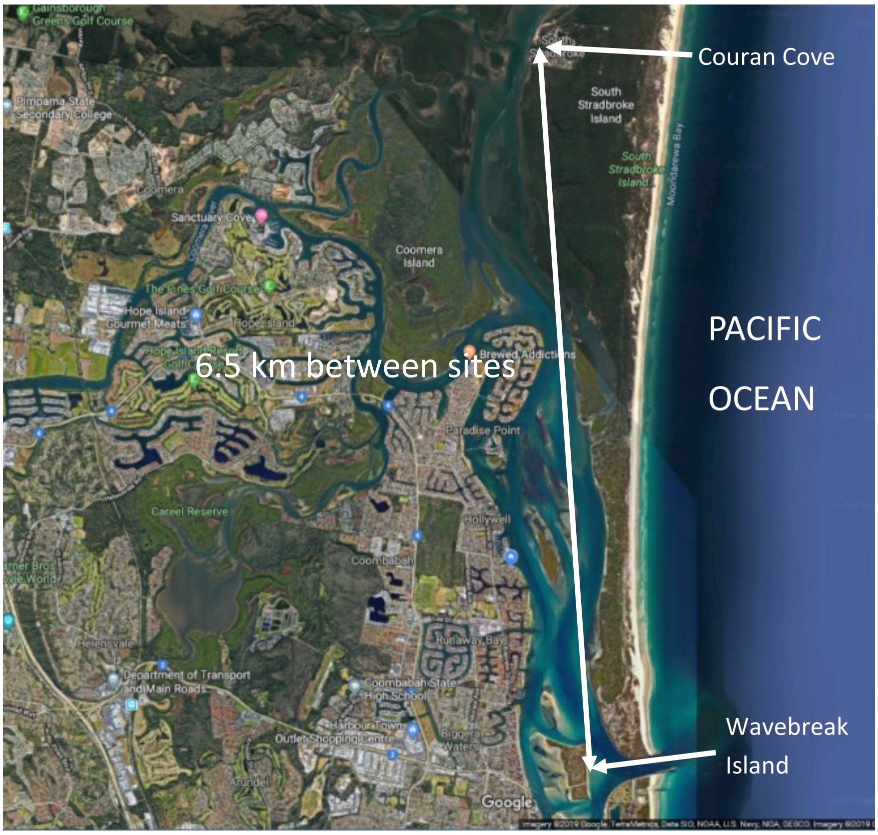


Fig.4. Map displaying the proximity of Couran Cove and Wavebreak island in relation to each other and the Pacific Ocean

Modification of A.R.M.S.
(Incorporation of Data loggers)

During the development of the Changing Ocean Program a large amount of time was spent searching for a site that would be complimentary to that of Wavebreak Island. The alternative site needed to display very different physical parameters to those experienced at Wavebreak Island.

In order to measure those physical parameters we used light and temperature HOBO data loggers (**see Fig.5**) that were capable of being submersed in water for extended periods of time. Traditionally high school environmental investigations are sometimes limited by data collection that occurs at a single point in time, hence the evaluation of that data may be considered limited in its scope.

We therefore ensured that the Changing Ocean program of study investigates the physical parameters of ocean water that have been collected over a significant period of time, in this case seven weeks.

During the research and development stage the physical variables that were measured were those of light and temperature but for a more robust investigation we have also incorporated water current measurements. The water current measurements are acquired through the use of the Marotte HS Current Meter that was developed and supplied by James Cook University (**see Fig.6**). The specifications and percentage error of these data loggers can be obtained through download via the International Marine Science Database website (IMSD).

https://internationalmarinesciencedatabase.com/changing-ocean-program

Fig. 5. Light and Temperature data logger that is attached to each ARMS unit (HOBO)

The light and temperature data loggers are attached to the ARMS for the duration of their deployment whilst the water current meter is deployed independently at each site and the data is collected periodically from each device throughout the data collection periods. Therefore some participants may notice discrepancies between the dates of deployment of their ARMS and the corresponding water current meter recorded data i.e. the dates may not match perfectly but the data will be concurrent.

Fig. 6. Marotte HS water current meter (JCU Marine Geophysics Laboratory)

The two primary sites used during the Changing Ocean Program have been selected due to their relative close proximity to each other whilst exhibiting very different physical parameters.

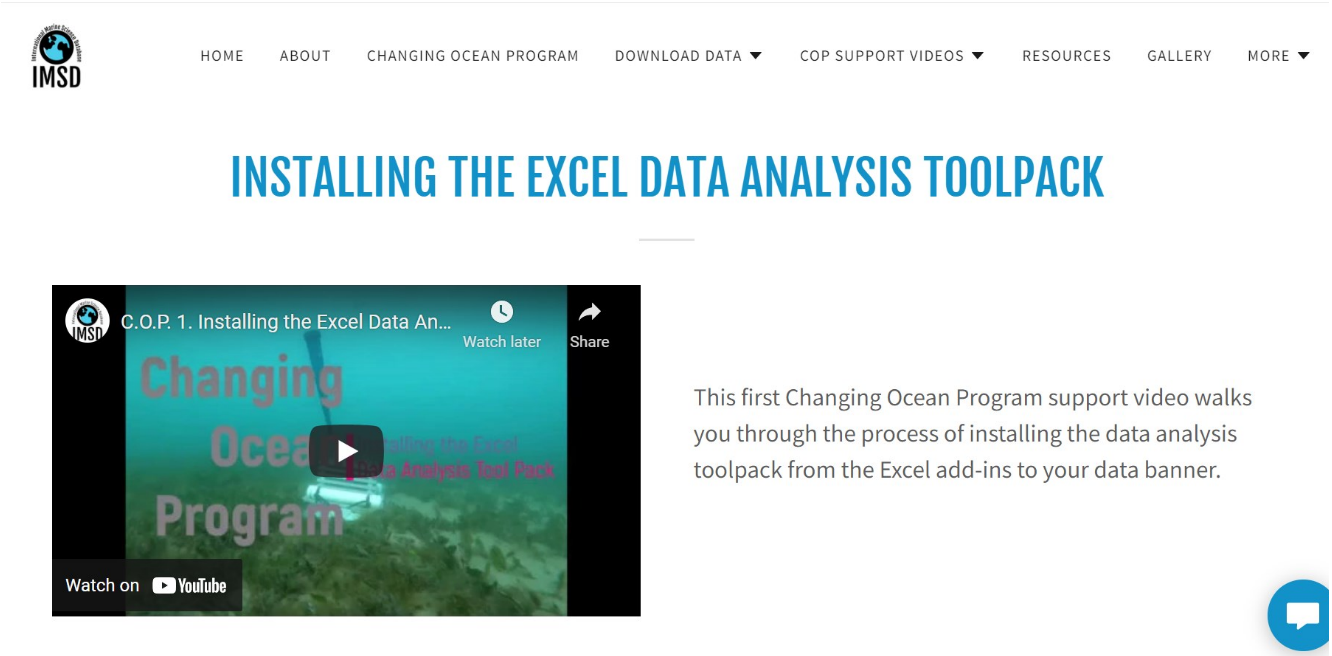
The data loggers are set to collect data at specified periods during their deployment. The HOBO light and temperature loggers are set to record measurements every five minutes whilst the Marotte HS current meter will record current speed every ten minutes. Although the data loggers cannot be deployed at exactly the same time (unfortunately we can't be in two places at once), participants can manipulate the data whilst performing statistical analysis in MS Excel.

The amount of data collected over a seven week period is substantial and hence the removal of relatively small amounts of data form the beginning and end of data collection periods is not too significant. This ensures that the comparison of data occurs between sites for exactly the same time periods. How to videos can be viewed at the International Marine Science Database (IMSD) website:-

Statistical Analysis Support Videos

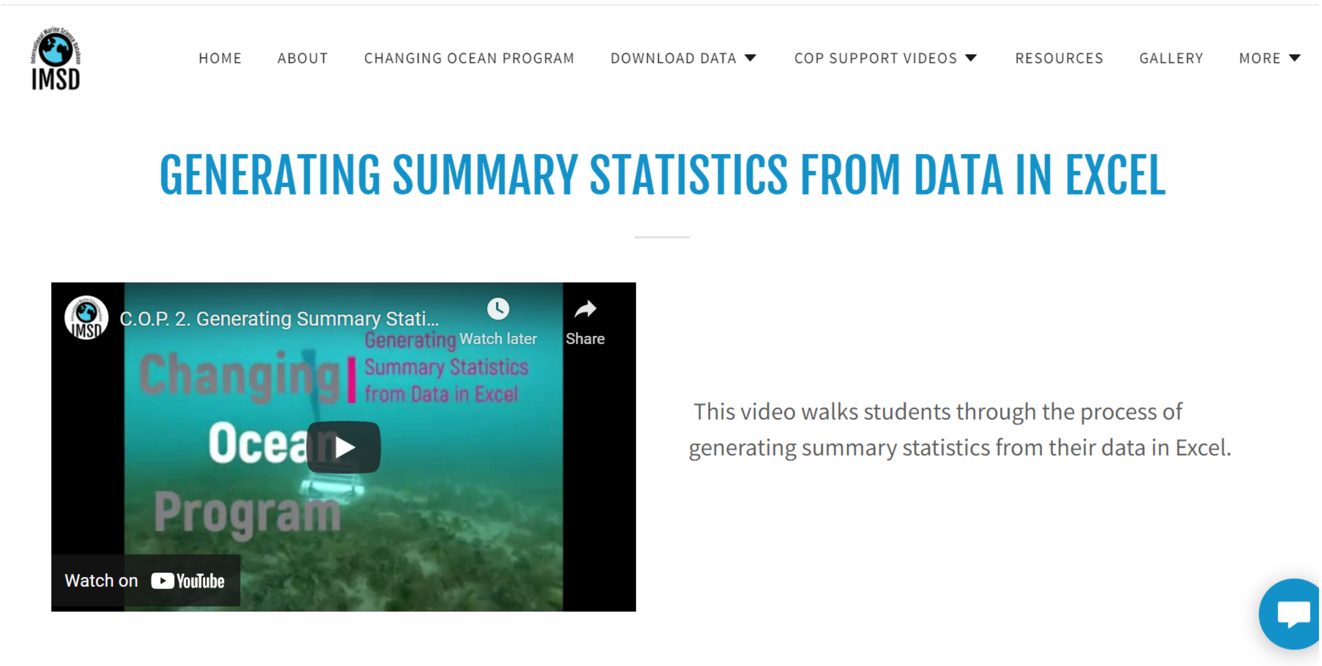
1. This first Changing Ocean Program support video walks you through the process of installing the data analysis toolpack from the Excel add-ins to your data banner.

https://internationalmarinesciencedatabase.com/cop-1-excel-data-analysis



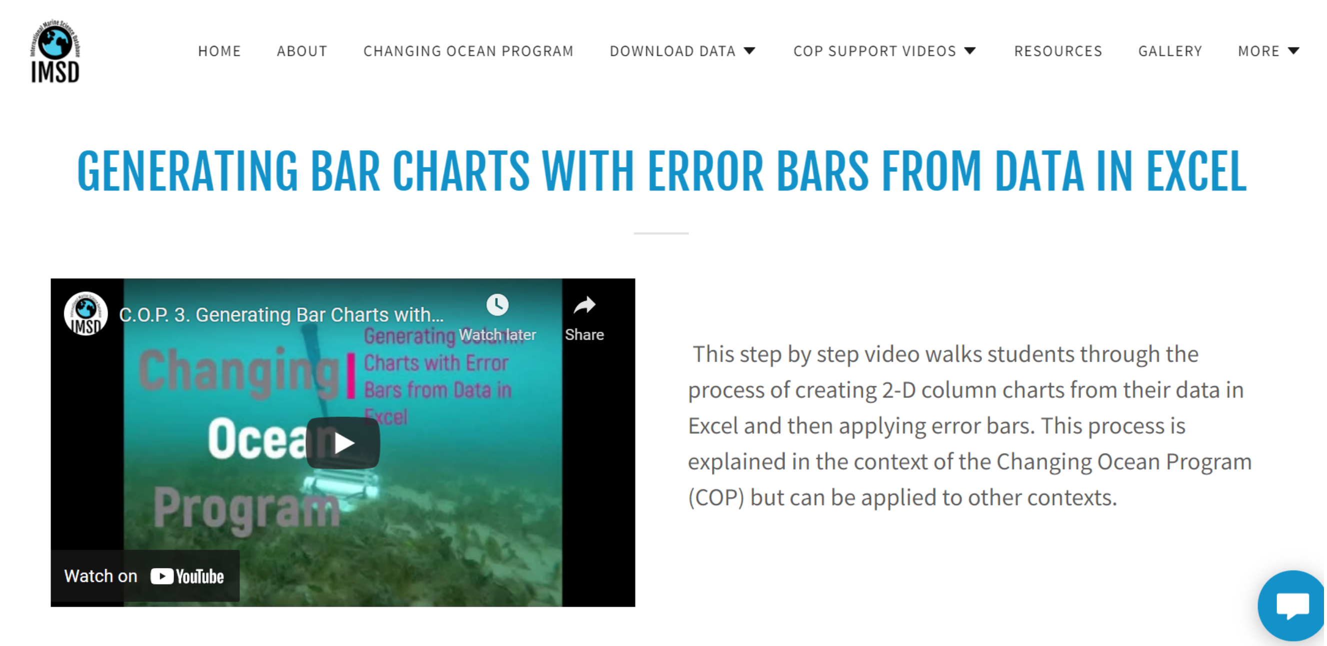
2. This video walks students through the process of generating summary statistics from their data in Excel.

https://internationalmarinesciencedatabase.com/cop-2-summary-statistics



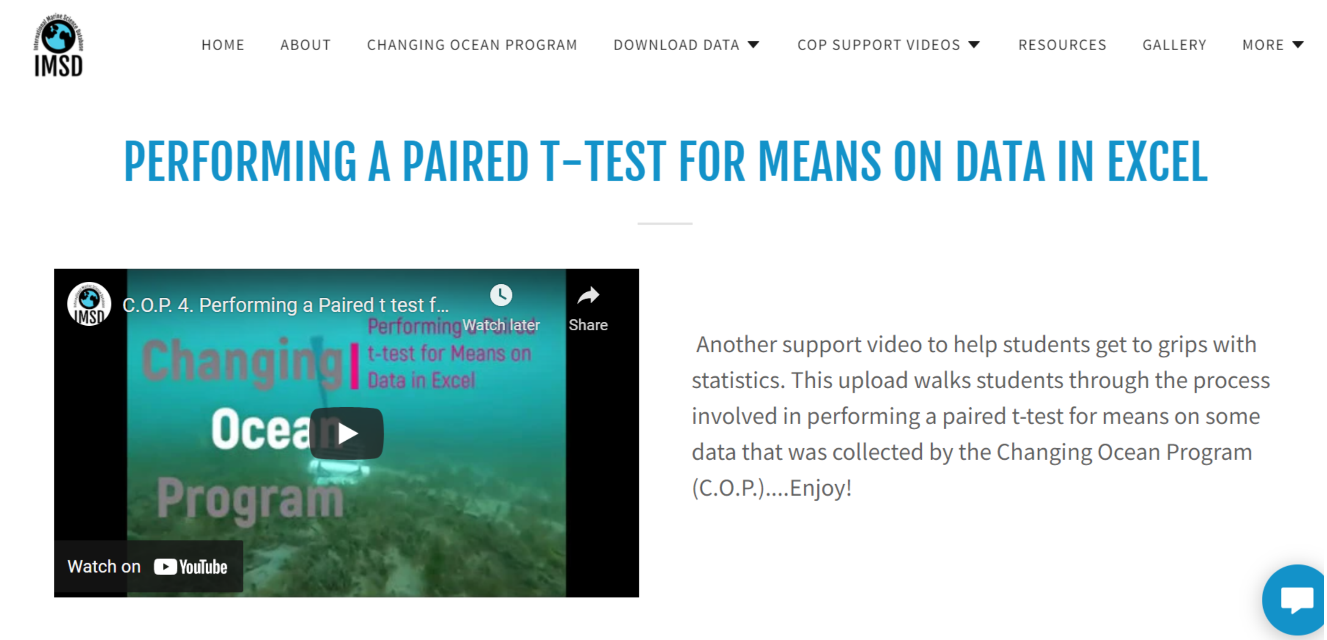
3. This step by step video walks students through the process of creating 2-D column charts from their data in Excel and then applying error bars. This process is explained in the context of the Changing Ocean Program (COP) but can be applied to other contexts.

https://internationalmarinesciencedatabase.com/cop-3-column-charts



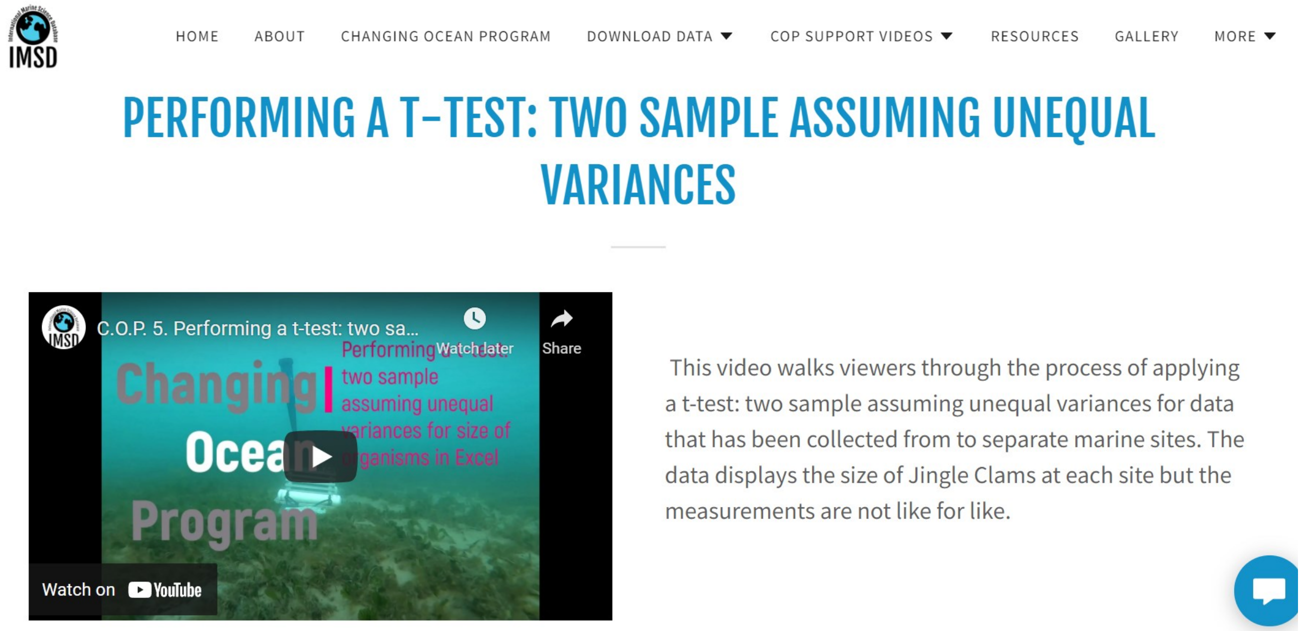
4. Another support video to help students get to grips with statistics. This upload walks students through the process involved in performing a paired t-test for means on some data that was collected by the Changing Ocean Program (C.O.P.)....Enjoy!

https://internationalmarinesciencedatabase.com/cop-4-paired-t-test



5. This video walks viewers through the process of applying a t-test: two sample assuming unequal variances for data that has been collected from to separate marine sites. The data displays the size of Jingle Clams at each site but the measurements are not like for like.

https://internationalmarinesciencedatabase.com/cop-5-t-test-unequal-1



Deployment of ARMS and data loggers

The deployment of the ARMS and data loggers ideally occurs on the same day although not at exactly the same time. This anomaly can be rectified during the data analysis period of the investigation (see statistical analysis)

The 'clean' ARMS and configured data loggers are deployed by boat and diver at Wavebreak Island on the eastern edge of the seagrass meadow. The site is revisited every week to ensure that the equipment has not been disturbed by boat anchor. The data loggers are also cleaned weekly to ensure accuracy of readings. Particular attention is given to the small window on the light/temperature logger to remove any algae or sediment build up that could reduce actual light readings.

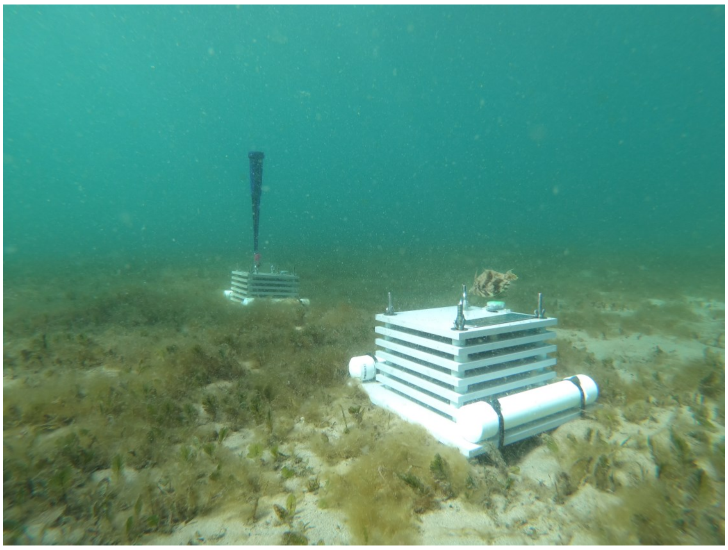
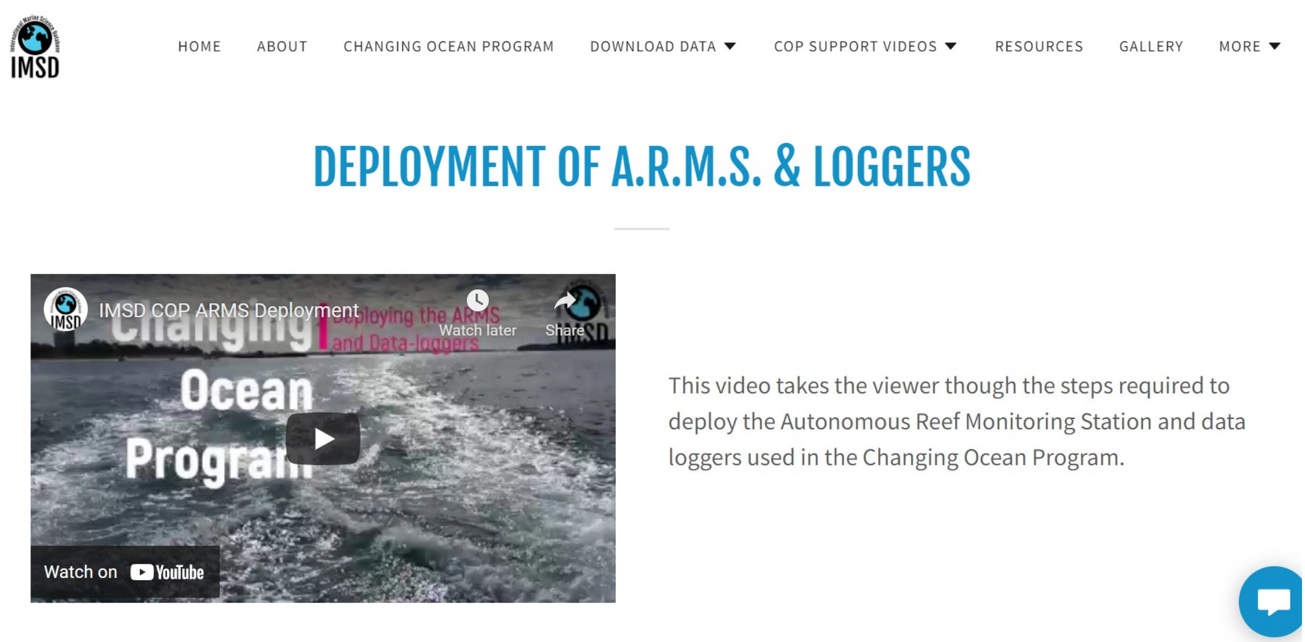


Fig.7. 'Clean' ARMS and loggers on deployment day (Harrison 2019)

The body of the Marotte HS current meter is also brushed by hand on a weekly basis to ensure against bio-fouling by algae and calcifying marine animals such as barnacles. The build up of these organisms will impact upon the accuracy of the water current readings. The current meter determines the speed of current flow by interpreting the angle of displacement from its buoyant vertical position when not deflected by a current. If compromised by an increased mass or surface area due to biofouling, the displacement from vertical will be larger and hence yield a false reading.

The process involved in the deployment of the Changing Ocean Program ARMS is outlined in a video that can be viewed on the International Marine Science Database website (IMSD) at:-

https://internationalmarinesciencedatabase.com/cop-6-deployment-of-arms



Data collection

The data collected from the ARMS falls into two categories:

1. Biotic data.

The six horizontal plates that comprise the unit provide sessile planktonic organisms a site on which to settle. The unit also provides sanctuary and resources for motile organisms but due to the disruptive retrieval process and transient lifestyle of the motile organisms, we cannot rely on the validity of the results for these organisms. Therefore we only consider the sessile animals that settle on the structure.

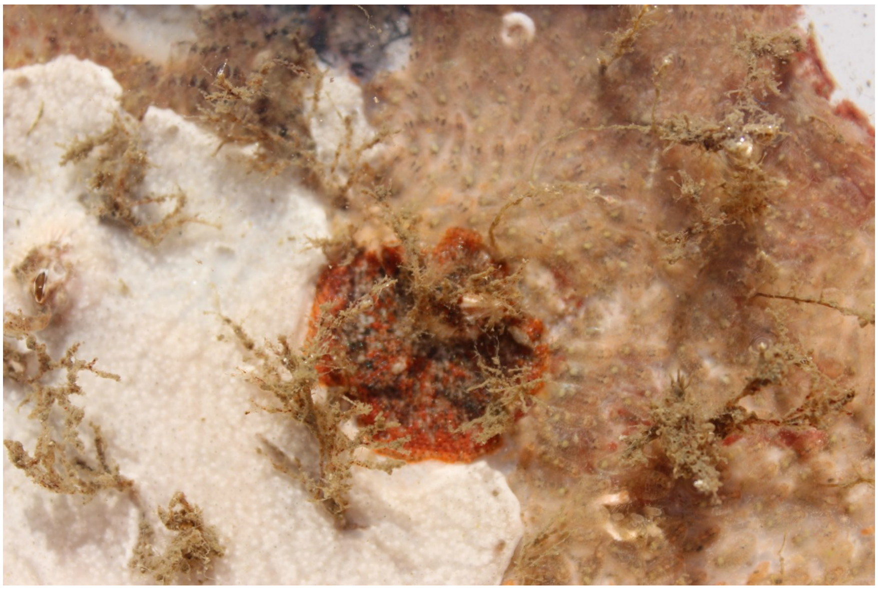


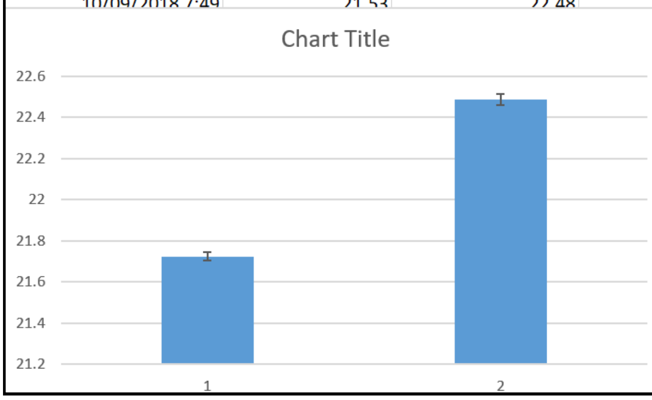
Fig.8. A community of Tunicates and Bryozoans cover areas of the ARMS plates (Harrison 2018)

2. Abiotic data. The abiotic factors that are currently being monitored are some of the physical aspects of the Ocean. These include the **water temperature**, the speed of **water current** flow over the ARMS and the amount of **ligh**t that penetrates down to the ARMS through the water column.

These physical parameters can have a direct impact on the settlement capacity of the planktonic organisms but may also be interpreted to suggest impacts of other factors that may affect the success of the organisms that have settled.

Using light level as an example of the interpretation of data. It could be suggested that comparatively low light levels can infer that large amounts of particulate matter is suspended in the water therefore dissipating the light and reducing the level of light reaching the light sensor on the ARMS. This particulate matter could be inorganic sediment, organic detritus or alternatively increased abundance of phytoplankton due to seasonal variation or increased eutrophication. This interpretation is valid and can be used by students to consider and formulate further investigation.

	Wavebreak Temp	Couran Temperature
10/09/2018 7:19	21.96	22.48
10/09/2018 7:24	21.49	22.48
10/09/2018 7:29	21.4	22.52
10/09/2018 7:34	21.4	22.48
10/09/2018 7:39	21.45	22.52
10/09/2018 7:44	21.45	22.52
10/09/2018 7:49	21.53	22.48



	Wavebreak Temp	*Couran Temp*
Mean	21.72376	22.48535147
Standard Error	0.018611	0.027356282
Median	21.75	22.78
Mode	22.78	25.14
Standard Deviation	1.199529	1.76315432
Sample Variance	1.43887	3.108713156
Kurtosis	-0.93848	-1.241578389
Skewness	0.18349	-0.113573739
Range	5.45	5.87
Minimum	19.6	19.52
Maximum	25.05	25.39
Sum	90240.48	93404.15
Count	4154	4154

t-Test: Paired Two Sample for Means

	Wavebreak	*Variable 2*
Mean	21.72376	22.48535147
Variance	1.43887	3.108713156

Fig.9. Statistical analysis of temperature data from Wavebreak Island and Couran Cove Marina using Microsoft Excel.

Influence of Light on Marine Biota

The vast majority of energy that moves through the ecosystems of Earth comes directly or indirectly from the Sun at the centre of our solar system. The light energy from the Sun is captured by autotrophic organisms that have the capacity to photosynthesise. These organisms fall into a category termed primary producers.

Fig.10. Sunrise over Crab Island, Queensland (Harrison 2020)

The vast majority of autotrophic organisms that reside on our planet use light as the energy source for the production of an energy storage molecule called Adenosine Tri-Phosphate (ATP). ATP is then used by the organism for metabolic processes. Some examples of those metabolic processes include the production of proteins and the production of simple and complex carbohydrates.

The simple carbohydrates, such as Glucose, are available for use by organisms through the process of cellular respiration. During cellular respiration Glucose can be readily oxidised and the bond energy that is released can be made available for use in the previously mentioned metabolic processes. If the simple carbohydrates are available in abundance and are not required then the autotroph may store those carbohydrates in a complex form such as starch. Starches can be broken down back into the simple carbohydrate form if required at a later time. These organisms that produce their own 'food' are termed primary producers (autotroph). The by-product of photosynthesis is the production of oxygen which, of course, is required by all the aerobic organisms that perform cellular respiration.

The photosynthetic process can be represented using the following simple formula:-

$$\underset{\text{Carbon Dioxide}}{6CO_2} + \underset{\text{Water}}{6H_2O} \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \underset{\text{Carbohydrate}}{C_6H_{12}O_6} + \underset{\text{Oxygen}}{6O_2}$$

Fig.11. Simple chemical formula representing the basic photosynthetic process

Therefore, we consider photosynthesising organisms such as plants and algae to be a vital link in the chain of the carbon cycle. These organisms sequester (absorb and lock away) large amounts of carbon dioxide from the environment (both atmosphere & hydrosphere) and release oxygen for the use of all organisms that require oxygen for cellular respiration. The reactants or 'ingredients' required for the process of photosynthesis are readily available within the marine environment. Ocean water is everywhere and the availability of carbon dioxide is increasing exponentially as the combustion of fossil fuels increases in an attempt to fulfil the energy requirements of an increasing human population.

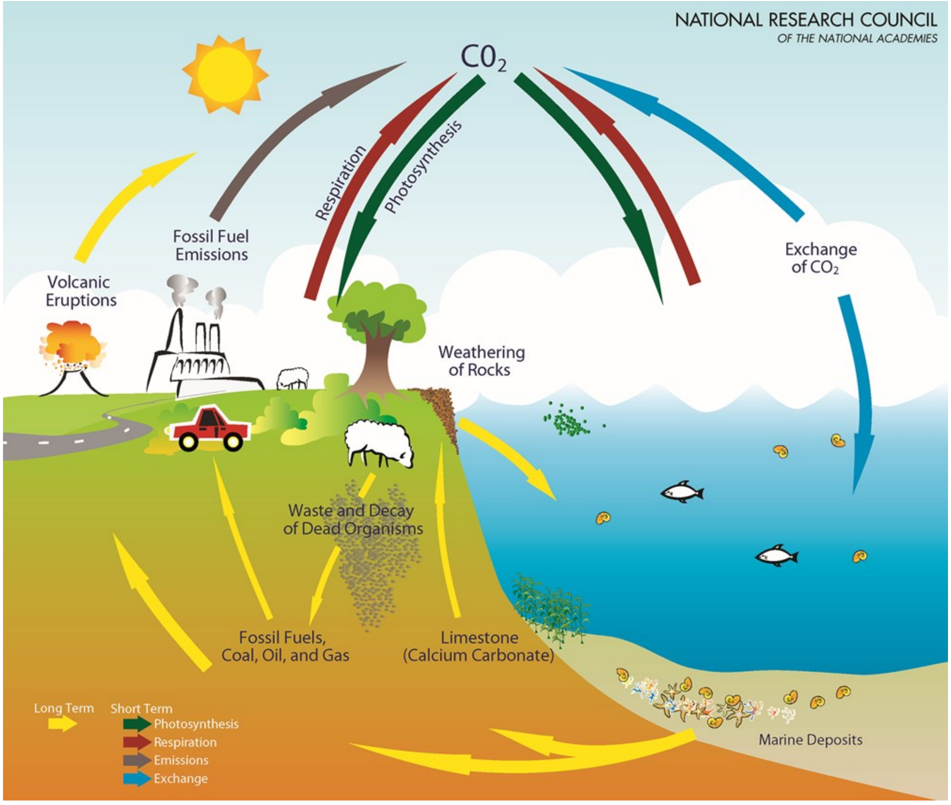


Fig.12. The Carbon Cycle (National Academies of Science)

The availability of sunlight that is required to drive the photosynthetic process is not in question, but the distance that it can penetrate down into the water column can be affected by suspended particulate matter. These suspended particles can diffuse the light and decrease the intensity of the light that reaches the seafloor. The light intensity will impact the efficiency of photosynthesising primary producers such as phytoplankton, algae and seagrasses **(see fig.13)**.

The amount and the size of inorganic suspended particulate matter can vary dependent upon the size of the particles and the speed of the water current flow that carries them. Faster water current will carry larger particles than slower water current flow.

Particulate matter can also take the form of biota such as phytoplankton. The Changing Ocean Program currently uses a light logger to record light intensities at the ARMS. Therefore students will need to be mindful of what type of suspended matter is causing diffusion of the light i.e. biota or inorganic matter. We are currently working on acquiring a logger that will record the amount of phytoplankton in the water column.

Increases in the amount of planktonic organisms can have a positive impact on filter feeding organisms such as the Jingle Clam **(see fig.14)** An abundance of phytoplankton provides a great food resource for these filtering organisms.

Fig.13. Halodule & Halophila seagrasses at Wavebreak Island, Queensland, Australia (Harrison 2018)

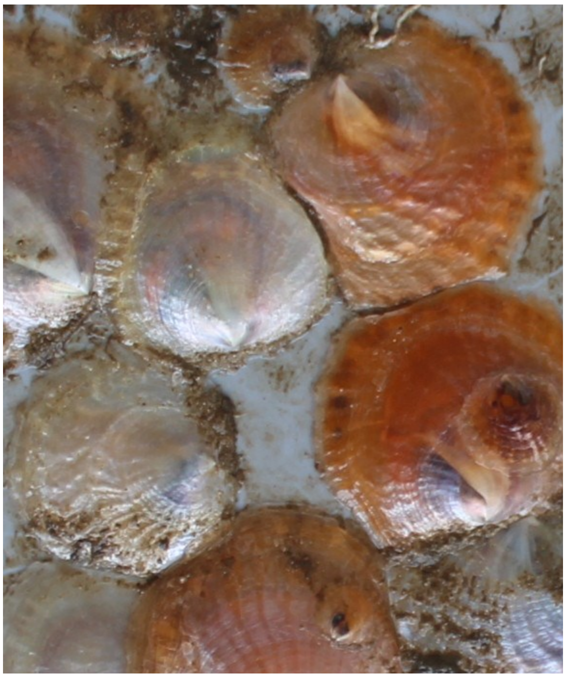


Fig.14. Jingle Clams growing on an ARMS plate (Harrison 2020)

Organisms such as colonial tunicates **(see fig.16)**, bryozoans **(see fig.17)** and barnacles **(see fig.18)** may also benefit from greater amounts of food resource through the increased abundance of phytoplankton and organic matter that is available in the water column.

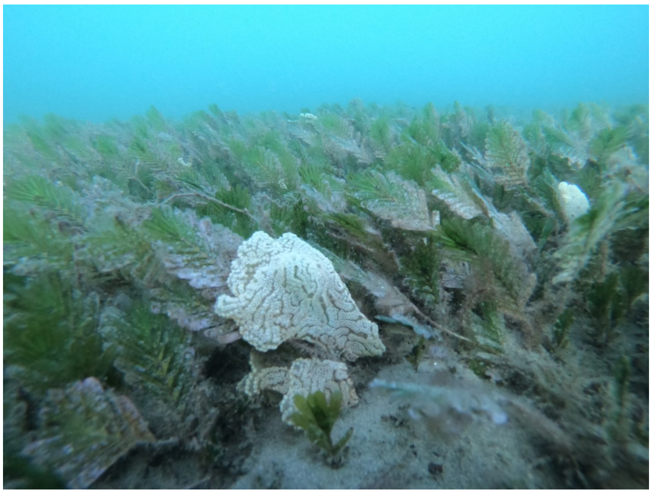


Fig.16. Colony of Botryllus tunicates growing on Halophila spinulosa seagrass at Wavebreak Island (Harrison 2019)

Fig.17. Encrusting Colony of Bryozoa growing on ARMS plate. Note the extension of lophophores as zooid feeds (Jeziorski 2020)

Plentiful resources for growth and development of macrophytes including macroalgae and seagrasses will lead to an increased surface area available for settlement of sessile planktonic organisms. This will lead to a greater complexity to the ecosystem and hence biodiversity, as greater numbers of marine species attend the area and obtain resources such as food and shelter.

Fig.18. Red striped Estuarine Barnacle attached to ARMS plate. Note the extension of the cirri as the organism attempts to feed. (Jeziorski 2020)

Topic 2: Ecosystem dynamics

A. Functioning ecosystems

In the **subject matter** of this topic students are asked to perform the following tasks that are relevant to the Changing Ocean Program:

1. Sequence and explain the transfer and transformation of solar energy into biomass as it flows through biotic components of an ecosystem, including

- converting light to chemical energy
- producing biomass and interacting with components of the carbon cycle

2. Describe the transfer and transformation of matter as it cycles through ecosystems (water, carbon and nitrogen)

An Example of the Influence of Water Temperature & Light on Marine Biota

Water temperature can play a significant role in the photosynthetic rate of aquatic autotrophs. Photosynthesising organisms will experience a thermal zone within which the photosynthetic rate is at an optimum. An example of this is the relative growth constants of the marine phytoplankton *Isochrysis galbana* when exposed to a variety of water temperatures. Under investigation this marine phytoplankton's growth constant between 20°c and 25°c was optimal; at 30°c no growth took place, but exposure for a week to this temperature was not lethal as cultures returned to 20°c were able to grow (Kain, J. 1958)

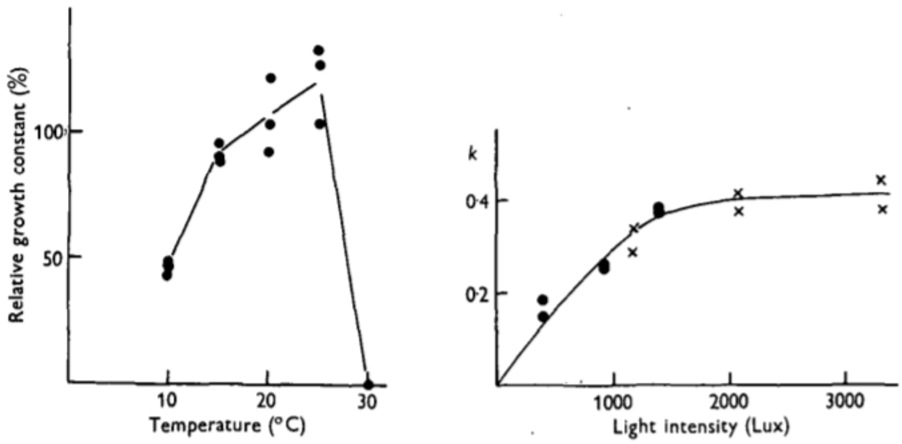


Fig.19. Graphs representing the relative growth constants of the marine phytoplankton *Isochrysis galbana* plotted against Temperature (°c) and Light intensity (Lux). (adapted from Kain, J. 1958)

These results would indicate that phytoplankton sp. abundance would change with seasonal fluctuations in temperature and light. Other water parameters could impact upon these results such as the availability of nitrates and phosphates.

Many filter feeding marine biota such as bivalve molluscs and cirripedia will be influenced by the availability of phytoplankton as a food resource. It may be suggested that the growth of these filter feeding organisms may correlate with the abundance of this food resource.

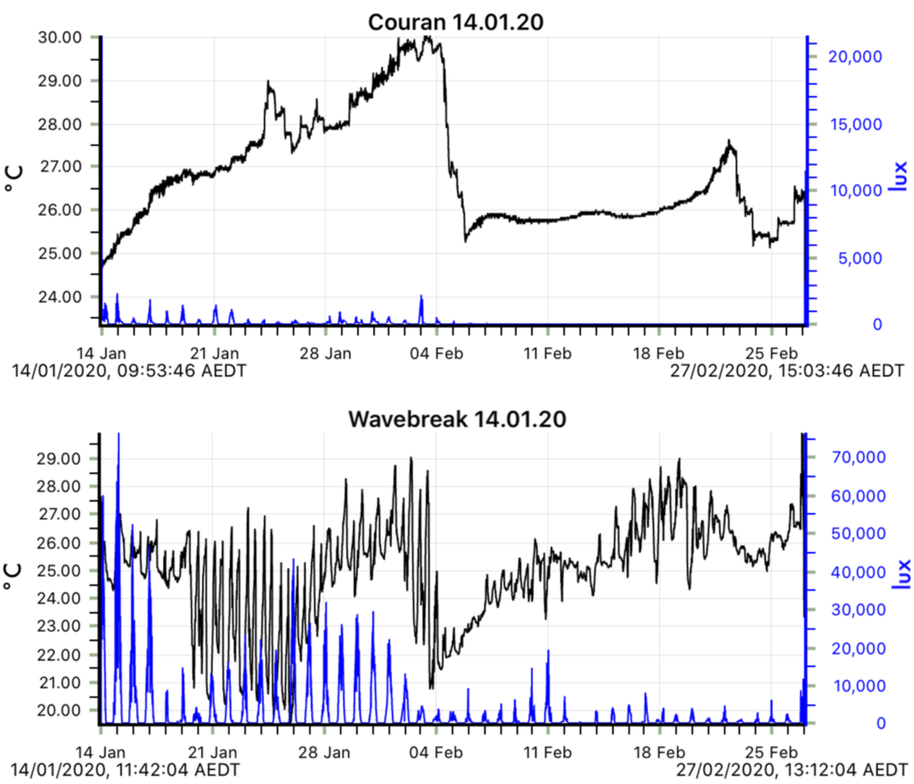


Fig.20. Comparative light (Lux) and water temperature (°c) data recorded from January through February 2020 at Couran Cove and Wavebreak Island (IMSD — HOBO Light & Temperature data logger 2020)

An Example of the Possible Influence of Water Current on Marine Biota

The speed of the water current that provides resources such as food and oxygen for the already settled marine biota can, in some cases, play a significant role in their success. Whilst other organisms are not impacted.

As an example it is suggested that the oxygen uptake of the Common Mussel (*Mytilus edulis*) is found not to be impacted by the water current speed (S. Irwin, 2006). Laboratory research showed that the rate of ciliary action in this bivalve mollusc was enough to compensate for static water surrounding the mussel. Although the feeding filtration rate of bivalve molluscs has been found to increase with an increase in water current speed (Walne, P. 1972)

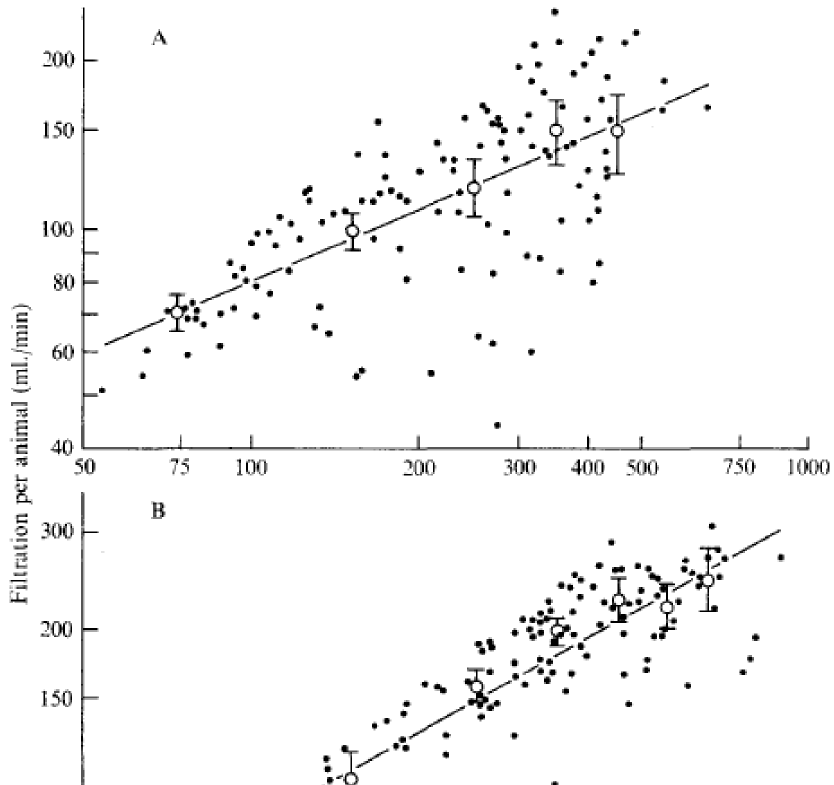


Fig.21. Graphs showing the relationship between animal filtration rate and flow rate of surrounding water for the Common Mussel (*Mytilus edulis*) and the Pacific Oyster (*Crassostrea gigas*) Adapted from Walne, P. (1972)

The previous examples of the impacts of the physical water parameters on bivalve molluscs, barnacles and phytoplankton are only a small representation of the possible combinations that students can investigate from the data collected.

The Assessment

The deployment of the ARMS and the data-loggers occurs seven weeks prior to their recovery. This provides an appropriate amount of time for planktonic organisms to settle on to the plates of the ARMS. Students will recover the ARMS from both sites and identify and quantify the organisms present.. This biotic data collection is used for the original purpose of investigating whether there is a marked difference in the biodiversity between the marine environments of Wavebreak Island and Couran Cove Marina.

Queensland Curriculum and Assessment Authority (QCAA) have set the student experiment for Unit 3: Biodiversity and the interconnectedness of life for the Biology IA2 task as follows:-

Students are asked to 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. (QCAA, 2019)

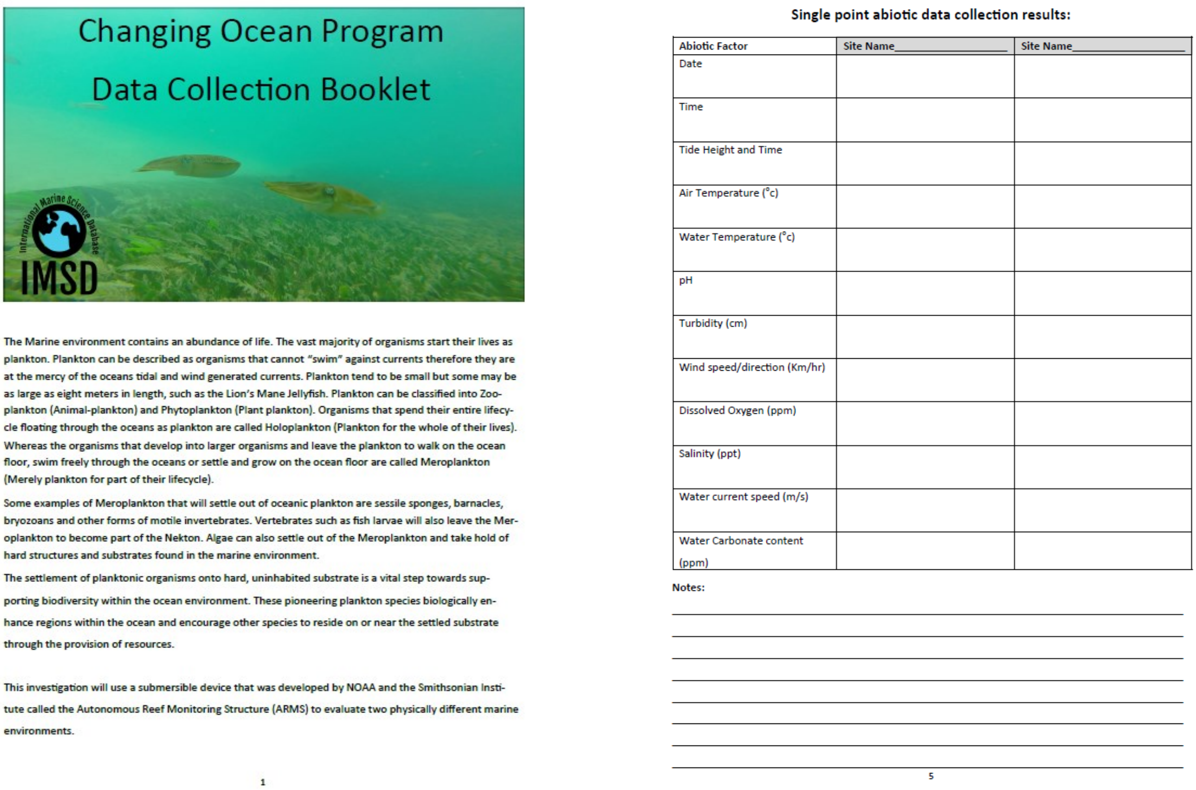
<u>Modification</u>

The Changing Ocean Program allows for the modification of the original intent which is the investigation into the biodiversity between to different but linked marine environments.

During the completion of the original investigation students notice a variety of trends and patterns that are displayed by the newly discovered sessile marine organisms. These trends and patterns will usually take the form of the abundance, size or distribution of an individual type of organism.

The exposition of life cycles occurs during the Changing Ocean Program and discussion around the impact of a variety of abiotic factors on these organisms will scaffold the development of research questions during the investigation.

A number of abiotic factors are measured and recorded at each site of the investigation. A list of those abiotic factors can be found in the text of the IMSD COP Student Data Collection Handbook 2021 (pdf) on page 5 titled Single Point Abiotic Data Collection Results, which can be accessed on the Changing Ocean Program web page of the IMSD website at https://internationalmarinesciencedatabase.com/changing-ocean-program.


Changing Ocean Program

Data Collection Booklet

The Marine environment contains an abundance of life. The vast majority of organisms start their lives as plankton. Plankton can be described as organisms that cannot "swim" against currents therefore they are at the mercy of the oceans tidal and wind generated currents. Plankton tend to be small but some may be as large as eight meters in length, such as the Lion's Mane Jellyfish. Plankton can be classified into Zooplankton (Animal-plankton) and Phytoplankton (Plant plankton). Organisms that spend their entire lifecycle floating through the oceans as plankton are called Holoplankton (Plankton for the whole of their lives). Whereas the organisms that develop into larger organisms and leave the plankton to walk on the ocean floor, swim freely through the oceans or settle and grow on the ocean floor are called Meroplankton (Merely plankton for part of their lifecycle).

Some examples of Meroplankton that will settle out of oceanic plankton are sessile sponges, barnacles, bryozoans and other forms of motile invertebrates. Vertebrates such as fish larvae will also leave the Meroplankton to become part of the Nekton. Algae can also settle out of the Meroplankton and take hold of hard structures and substrates found in the marine environment.

The settlement of planktonic organisms onto hard, uninhabited substrate is a vital step towards supporting biodiversity within the ocean environment. These pioneering plankton species biologically enhance regions within the ocean and encourage other species to reside on or near the settled substrate through the provision of resources.

This investigation will use a submersible device that was developed by NOAA and the Smithsonian Institute called the Autonomous Reef Monitoring Structure (ARMS) to evaluate two physically different marine environments.

1

Single point abiotic data collection results:

Abiotic Factor	Site Name__________	Site Name__________
Date		
Time		
Tide Height and Time		
Air Temperature (°c)		
Water Temperature (°c)		
pH		
Turbidity (cm)		
Wind speed/direction (Km/hr)		
Dissolved Oxygen (ppm)		
Salinity (ppt)		
Water current speed (m/s)		
Water Carbonate content (ppm)		

Notes:

5

Fig.22. Cover page and single point abiotic data collection page of the IMSD COP Student Data Collection Handbook 2021 (IMSD 2021)

Development of a research question

The QCAA call for the development of a research question. This question will be developed by the student based upon their observations, interest in a specific organism and the collected data. At this point it could be suggested that the students are encouraged to research their chosen organism. This research should include:-

• Morphology of the organism

• Reproductive strategy of the organism

• Feeding strategy of the organism

• Strategies for the acquisition of oxygen

This research will highlight aspects of the physical water parameters that may impact the sessile organisms that could be found on the ARMS plates.

Once the student has developed a research question it is advisable to support the student's attempt to obtain relevant information from suitable peer reviewed research papers. This information can then be used for justification in their rationale.

If required we can offer support to teachers during this process so please don't hesitate to get in touch with us. We can be contacted at iain@internationalmarinesciencedatabase.com.

Use of Abiotic Data Collected from Loggers

Once the student has established a research question the abiotic data that was collected during the deployment of the ARMS can be released to students. In most cases a student will investigate the impact of one physical water parameter on their chosen organism. The abiotic parameters that are collected:-

• Water current speed (ms^{-1})

• Water temperature (^{o}c)

• Light level at ARMS (Lux)

Details of how to perform statistical analysis on both the biotic and abiotic data can be viewed at the IMSD website under the COP Support Videos dropdown menu. In order to evaluate if there is a statistically significant difference between each set of data the data is processed using a t-test. Links to these videos can be found on pages 8, 9 and 10 of this booklet.

Spatial and Temporal Investigations

Although the majority of students will investigate the spatial difference i.e. how different the sites are from each other at the same point in time, there is an opportunity for students to also investigate temporal change at a site.

The IMSD website has data available for download that was recorded using the same methodology by other participants in the program at different times of the year. This allows for investigation into seasonality of organisms and the impact that this may have on their settlement.

These biotic and abiotic data sets are available for download from the Download Data dropdown menu at the IMSD website https://internationalmarinesciencedatabase.com/. e.g. https://internationalmarinesciencedatabase.com/december-2020.

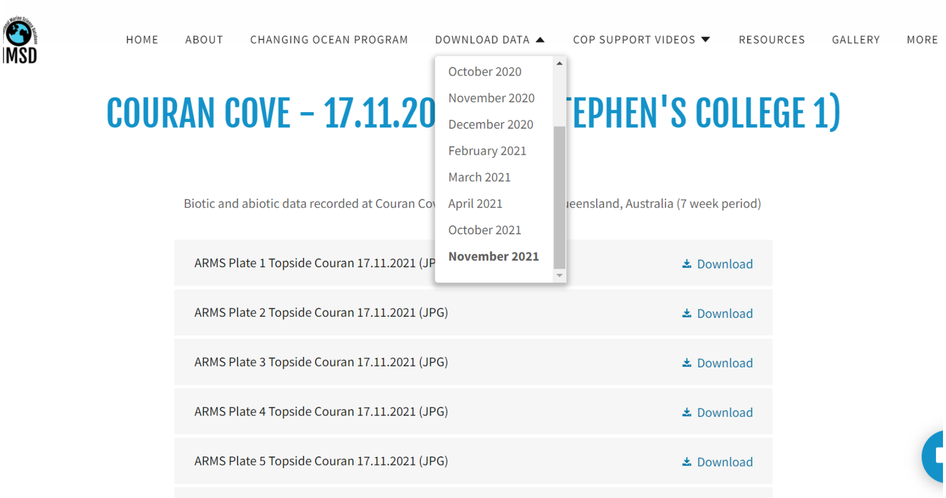


Fig.23. Dropdown menu for data download at IMSD website.

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