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Managing Marine Seascapes Through Community-based Conservation

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ABSTRACT

In this multi-component exercise, you have been recruited as community scientists to analyze real-world data collected in Vatu-i-Ra Seascape using non-destructive diver operated video (DOV) methods. These videos were previously collected by the Wildlife Conservation Society in collaboration with local divers in Fiji. Students will quantitatively analyze and use this data to assess the fisheries management efficacy of *tabu* areas—a traditional Fijian approach to create no-take, Marine Protected Areas—as a method of promoting marine biodiversity and improving overall ecosystem health using metrics such as fish abundance and coral reef complexity. During this exercise you will also learn about the importance and cultural significance of *tabu* areas in relation to ecosystem health and human livelihoods. You will be directed on how to visualize the results and summarize their conclusions through a written report in the style of a scientific journal article. In the discussion section of your scientific journal article, you are encouraged to critically think about study limitations and discuss future research directions to expand the project.

LEARNING OBJECTIVES

After completing this case-study based exercise, you will be able to:

1. Examine the ecological, cultural, economic, and social significance of fisheries management strategies.
2. Consider the strengths and weaknesses of the diver operated video (DOV) method.
3. Use DOV to assess the impact of *tabu* areas (MPA) on coral reef fish abundance and coral reef complexity.
4. Test hypotheses by analyzing and visualizing data.
5. Format research into the style of a scientific manuscript.

INTRODUCTION

Often referred to as the "rainforests of the sea", coral reefs are regarded as some of the most productive and biologically diverse ecosystems on the planet (Reaka-Kudla et al. 1996). Coral reefs provide a variety of ecosystem services to humans such as fisheries, coastal protection, water management, materials, and cultural benefits (Woodhead et al. 2019). However, coral reefs are susceptible to anthropogenic[1] disturbances such as climate change, pollution, habitat destruction, unsustainable fishing practices, and removal of keystone species[2] (Burke et al. 2011). These anthropogenic stressors disrupt critical ecosystem services coral reefs provide and are associated with global declines in fish populations, making conservation an international priority.

In response to coral reef degradation and global declines in fish populations, marine protected areas[3], or MPAs, are widely used to preserve marine biodiversity. MPAs are regions of the marine environment that have been designated to preserve nature (Grorud-Colvert et al. 2021). These areas are protected by various strategies, such as closures, management, or scientific study. There is substantial evidence to suggest that strictly enforced MPAs lead to increased biomass, fish size and density, biodiversity, resilience to natural disturbances, and livelihood security for fishing communities

(Edgar et al. 2014; Mellin et al. 2016; Roberts et al. 2001). In theory, MPAs are thought to positively affect adjacent fisheries through the "spillover effect," in which increases in biomass near the MPA borders move into fished areas (Di Lorenzo et al. 2020).

Located in the South Pacific region, the Fiji archipelago (1.3 million km^2 area) has one of the world's largest and most extensive coral reef systems. It is a critical site for marine conservation, home to an astounding 42 percent of all known coral species (Burke et al. 2011). Local communities in Fiji rely on the extensive ecosystem services of coral reefs for economic, cultural, and nutritional benefits—rendering it especially critical to ensure that marine protections are practical and beneficial (Mangubhai et al. 2019). The livelihoods of the local communities depend on the success of MPAs, therefore it is important to understand whether and how MPAs are effective for maintaining coral reef complexity and fish abundance. Much of the previously discussed research on protected areas has been conducted in areas with the highest level of protection, but locally managed marine areas (LMMAs) are an alternative where minimally destructive anthropogenic activity is allowed. Fiji is an example of a country that uses LMMAs to protect some of their coral reefs. Within the context of South Pacific culture, LMMAs are rooted in customary and traditional fisheries management practices designed to engage the community as stakeholders in the decision-making process (Doulman 1993). LMMAs with a definitive designation of areas that prohibit extractive uses are known as *tabu* areas (Robertson et al. 2020). The name *tabu*[4] (pronounced TAM-bo) comes from a customary Fijian fishery management tool in which fishing grounds (qoliqoli) are temporarily closed following the death of a community's chief.

The Vatu-i-Ra Conservation Park seascape

The Vatu-i-Ra Conservation Park covers over 100km^2 of marine and terrestrial ecosystems, including coral reefs, lagoons, and the island of Vatu-i-Ra (Figure 1). Management of the Conservation Park includes "no-take" zones (covering approximately 80% of the park) and "catch-and-release" zones, which allow sustainable, recreational fishing. The Conservation Park is home to over 100 species of fish, nine species of seabirds, and species of dolphins, whales, and sea turtles. Ideally, protection within the park encourages the growth of fish populations, causing a spillover effect in surrounding areas to support the adjacent traditional fishing ground (*qoliqoli*) of Cokovata Nakorotubu. Vatu-i-Ra Conservation Park is particularly vulnerable to impacts such as overfishing, invasive species, and climate change, and was damaged by Tropical Cyclone Winston in 2016.

OVERVIEW

In this assignment, you will generate data as a Community Scientist using previously collected Diver Operated Videos (DOVs; Figure 2) (Activity 1). Then, you will analyze the data your class produced (Activity 2) and draft a manuscript following the guidelines of the journal Conservation Biology (Activity 3).

ACTIVITY 1. DIVER OPERATED VIDEO DATA COLLECTION

Diver Operated Video (DOV): A non-invasive, non-destructive research method

The Wildlife Conservation Society, in collaboration with local divers in Fiji, created a series of diver operated videos (DOVs)[5] collected along transects[6] in the Vatu-i-Ra Marine Park. Through this activity, you will learn about the experimental design utilized by scientists and community members to collect the data. You will also assess the potential experimental errors of the study design and propose how to improve upon aspects of the experiment by considering the advantages and disadvantages of different underwater data collection methods. You will analyze the collected data and utilize numerical outputs to determine whether there is a difference in *tabu* and fished areas in the Vatu-i-Ra Seascape.

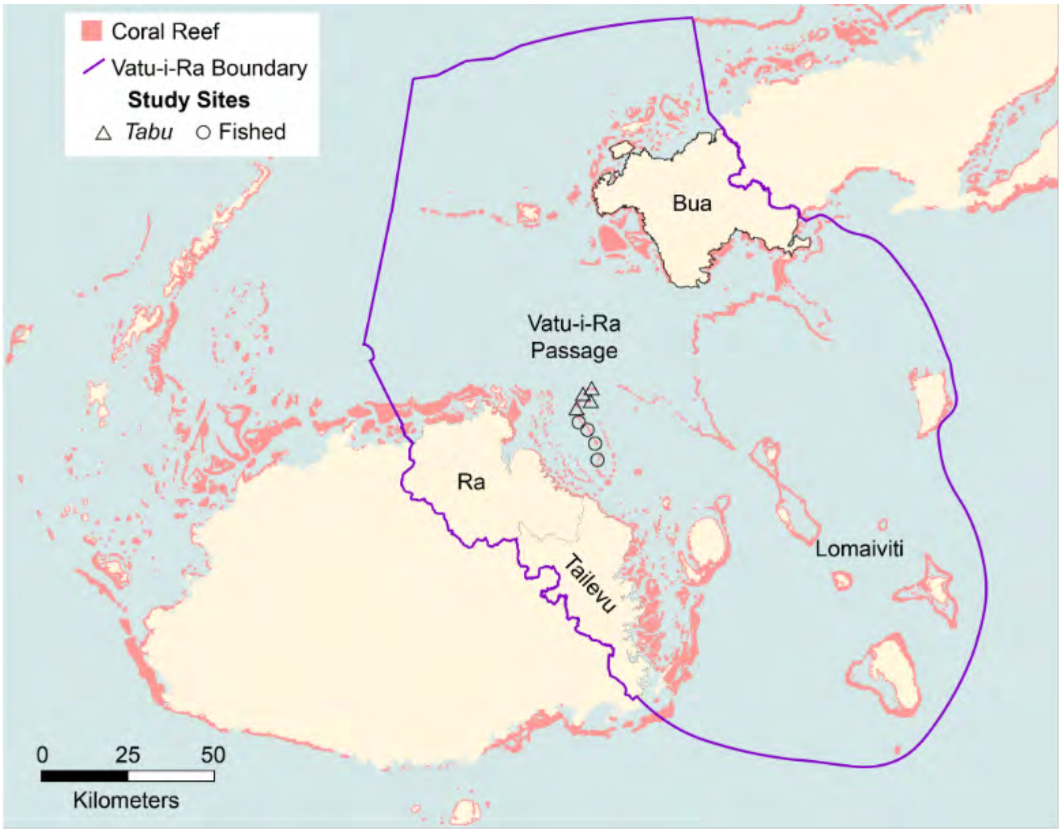


Figure 1. The Vatu-i-Ra Seascape is outlined in purple and includes four provinces in Fiji (Kastl and Gow 2014). Coral reefs are shown in pink (UNEP-WCMC et al. 2021), and study sites used in this exercise are represented by triangles and circles.

Figure 2. SCUBA diver conducting diver operated video (stereo-DOV) survey at Mo'orea, French Polynesia. Photo credit: Lauric Thiault/ Goetze et al. 2019.

Important links + resources

First, watch this ~7 minute DOV Methods video (https://methodsblog.com/2019/06/13/stereo-dov/) about advantages, methods, and applications of DOV in marine systems. (Note, you may be assigned to watch this video on your own, or watch it in class during the background lecture. Though the video describes two collection cameras, we will use only one of the two collection cameras in this assignment).

Then, review the journal article "A field and video analysis guide for diver operated stereo-video" (Goetze et al. 2019; https://doi.org/10.1111/2041-210X.13189) and especially pay attention to sections 1, 2, 7, and 9. Think about these questions: What are some advantages of DOVs? What are some limitations? How does standardizing collection methods help advance scientific knowledge?

Your instructor will assign specific DOV transects for you to analyze. Each video is an individual underwater transect.

The videos can be accessed here: YouTube—Diver-operated videos (DOV); https://www.youtube.com/playlist?list=PLc2xCMLuYq9asSAwIq7xQEDgQhGCk4MUE.

Part A. DOV transect protocol

- Download and use the DOV Data Entry Spreadsheet (provided by your instructor or downloaded from NCEP module collection at https://ncep.amnh.org) to add your data collected from the below protocol for each of your assigned video replicates: fish count and measurements of reef structural complexity.
- To submit: DOV data entry spreadsheet filled out for your videos.

For each video:

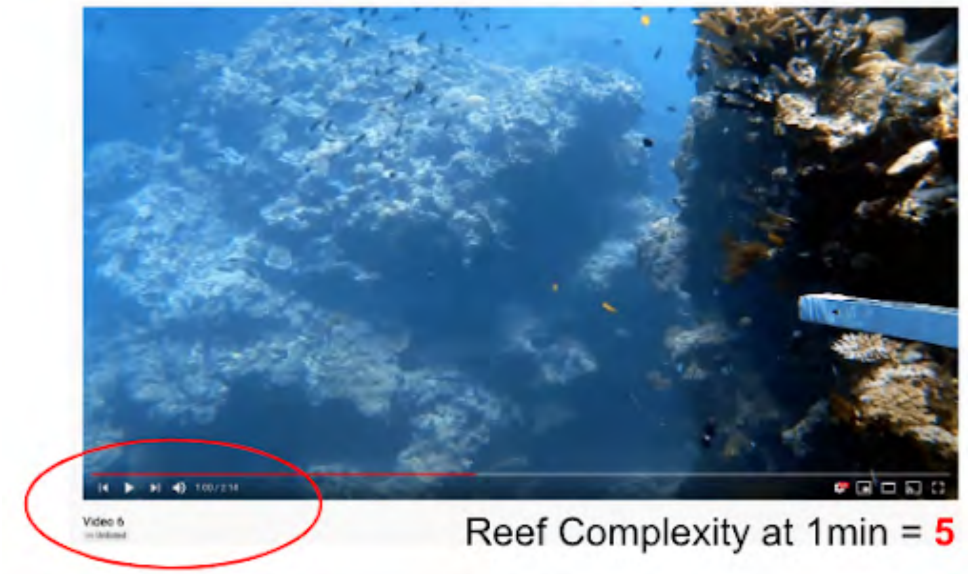
1. To enable more accurate counting, try to use a computer monitor or larger screen at eye level.
2. Set video to maximum quality (1080p) if possible.
3. Watch video at normal speed and write down the time where fish appear and group (no counting). At 5 timepoints every 20 seconds (0:20, 0:40, 1:00, 1:20, 1:40), pause the video and score the reef structural complexity from 1–5 using the categories described in Box 1 below, and enter the scores in the datasheet.
4. Watch the video a second time following these instructions:
   a. Slow the video by setting the speed to 0.25x.
   b. Start counting when the camera is stabilized after start. Use a counter with the app sound on (so you can hear it increase without looking at it)
   c. Use Pause when many fish quickly and suddenly appear in view
   d. For schooling pelagic fishes against blue water, count when you can clearly see the group of fishes
   e. For benthic fishes, look for movement against the reef background. Occasionally you may need to use Pause to count multiple fish in reef structures
   f. Use judgment to avoid double-counting: be mindful not to record anything that appears to come from behind the camera.
5. Submit the spreadsheet for this assignment to your instructor.

Part B. Structural complexity

- To submit: A Word document with a screenshot at each of the 5 timepoints and a complexity score for each screenshot.

Instructions:
1. For each DOV transect assigned, take screenshots at 5 timepoints (0:20, 0:40, 1:00, 1:20, 1:40) according to the protocol in Part A.
2. Create a Word document and, for each timepoint, paste in a screen shot from the video. On your document, type the video number, timepoint (0:20, 0:40, 1:00, 1:20, 1:40), and the structural complexity category for each timepoint.

Example for 1 timepoint screenshot at 1:00 for Video 6 with a Reef Complexity score of 5 (see Box 1):



- Submit the document that contains the 5 timepoint screenshots and associated information for each video you were assigned.

ACTIVITY 2. STATISTICAL ANALYSIS OF DATA

To share data with other researchers and the public, scientists must first make the data meaningful. One way scientists do this is by using statistics to determine whether there is a difference between averages of two groups of data. Here, you will use Excel to test the hypotheses that you will later write about in Activity 3. You will submit your three graphs and T-test[7] results to your instructor for grading. Note: Below instructions and screenshots may vary with different versions of Microsoft Excel. The functions required are relatively standard for many spreadsheet software versions, so use the Internet or help tools in the program to assist with variations.

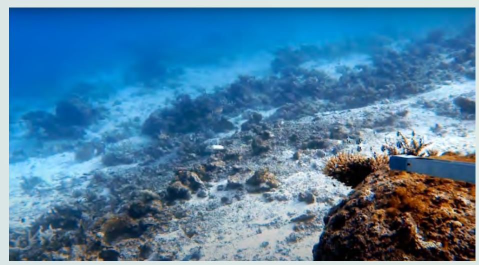
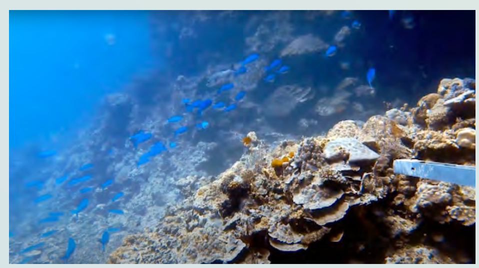
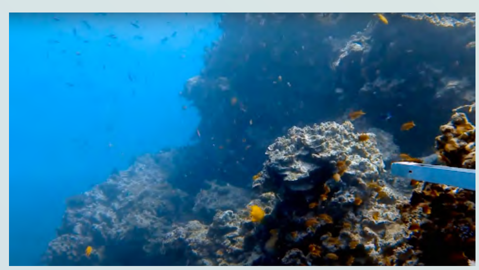
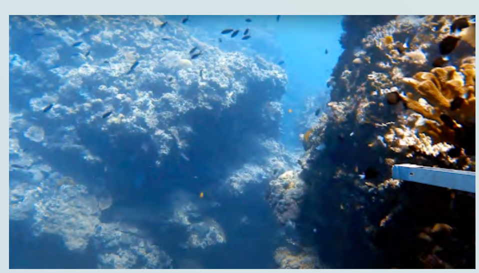
- To submit: Document with screenshot of coral complexity and fish count data, three graphs, and sample results sentences for each part (Appendix 1).

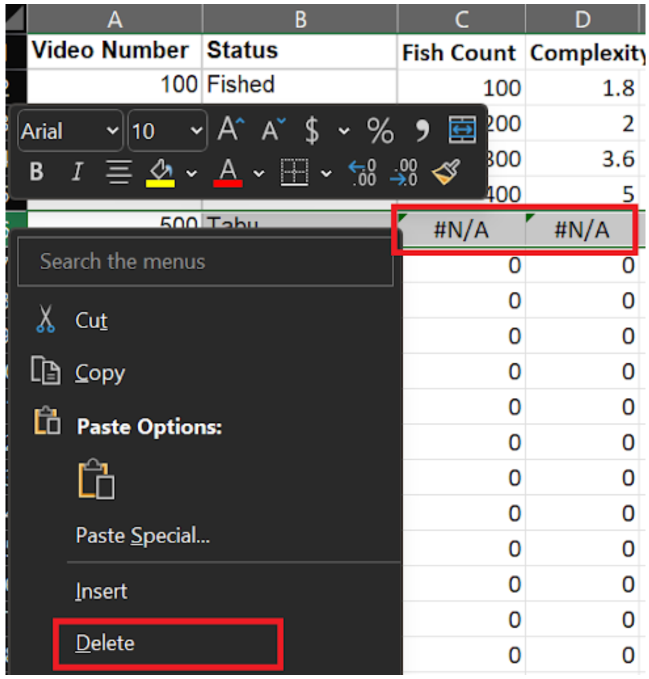
PART A. Test the hypothesis that *tabu* areas have different coral reef complexity compared to fished areas

1. Your instructor will provide you with an Excel spreadsheet that has combined all of the data from your class. Go to the tab titled "Video Data". This is the data you will be using to test your hypotheses.
2. Delete all video rows with missing data (shows as #N/A). These are the videos that your class did not analyze. To delete: highlight the row, right click, and select "Delete".

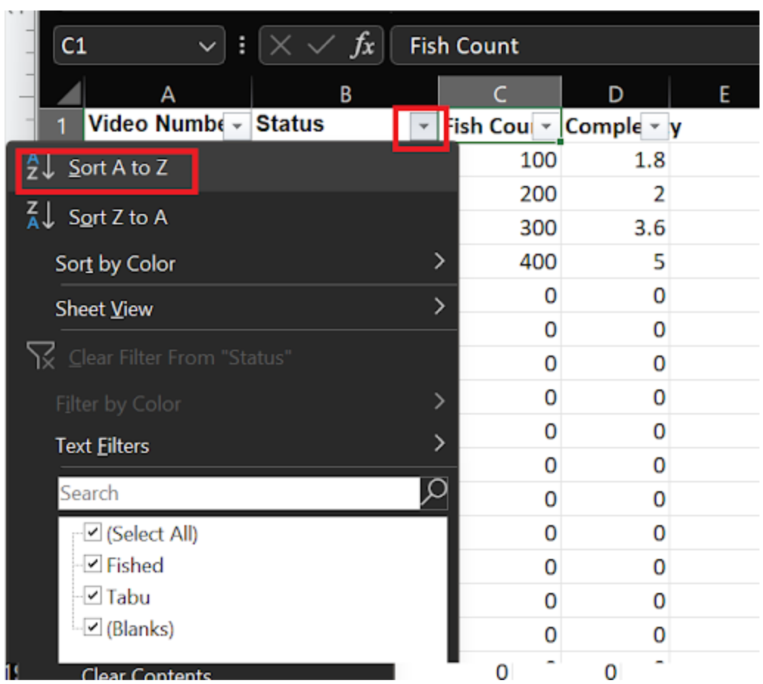
Box 1. Reef structural complexity

To measure structural complexity, you will be following the Williamson et al. 2004 categorical scaling system for coral reefs. As the observer, you will visually estimate the structural complexity of the reef slope for five timepoints in each video. See accompanying PowerPoint presentation for reference photos and additional examples.

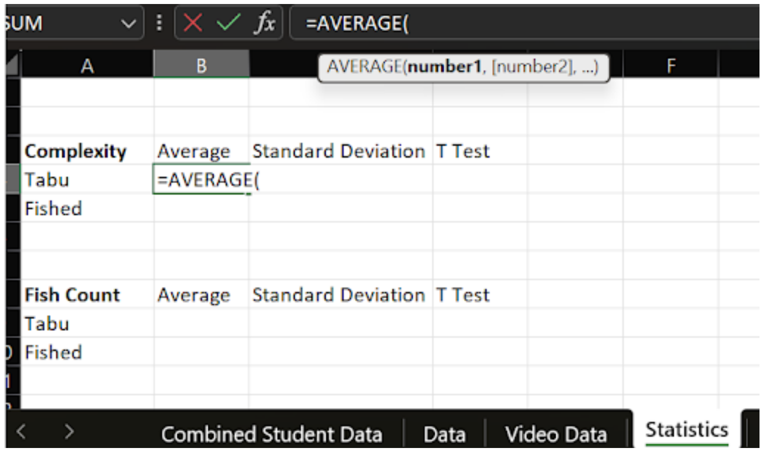
Category	Description	Example
1	Flat, sandy, expanses of rubble with some small scattered bommies (coral heads)	
2	Bommies amongst mostly rubble and sand. Reef slope < 45°	
3	Rubble amongst mostly coral bommies. Reef slope ~ 45°	
4	Good reef structure with some overhangs and holes. Reef slope >45°	
5	High reef complexity. Many overhangs, holes and caves. Large bommies. ~90° wall	

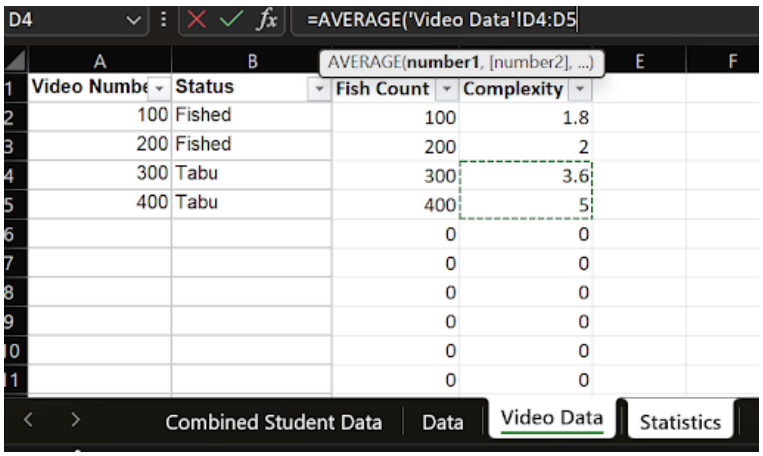


3. Sort by protection status. Click the dropdown arrow on "Status" and choose "Sort A to Z". Note: if there is not a dropdown arrow, highlight the first row and choose "Sort & Filter" > "Filter".

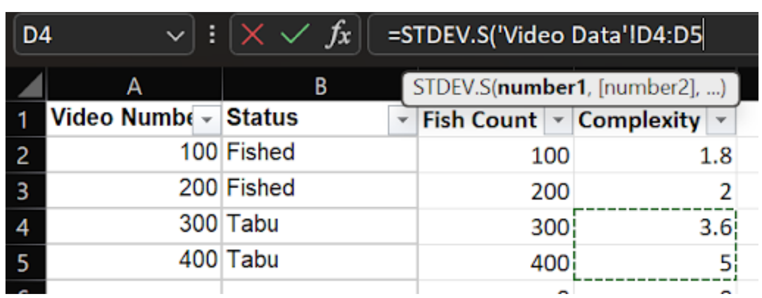


4. Go to the Statistics sheet. In the box for the average complexity of *tabu* areas, calculate the average complexity for the *tabu* areas from the Video Data sheet. To do so, type =AVERAGE(into the field. Then, navigate to the Video Data sheet and highlight the values to be averaged. Type) to close the formula and then hit enter.

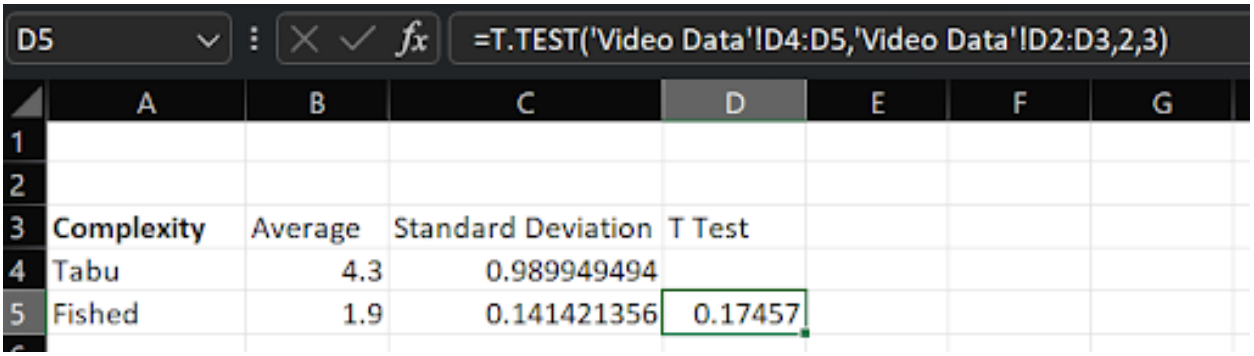




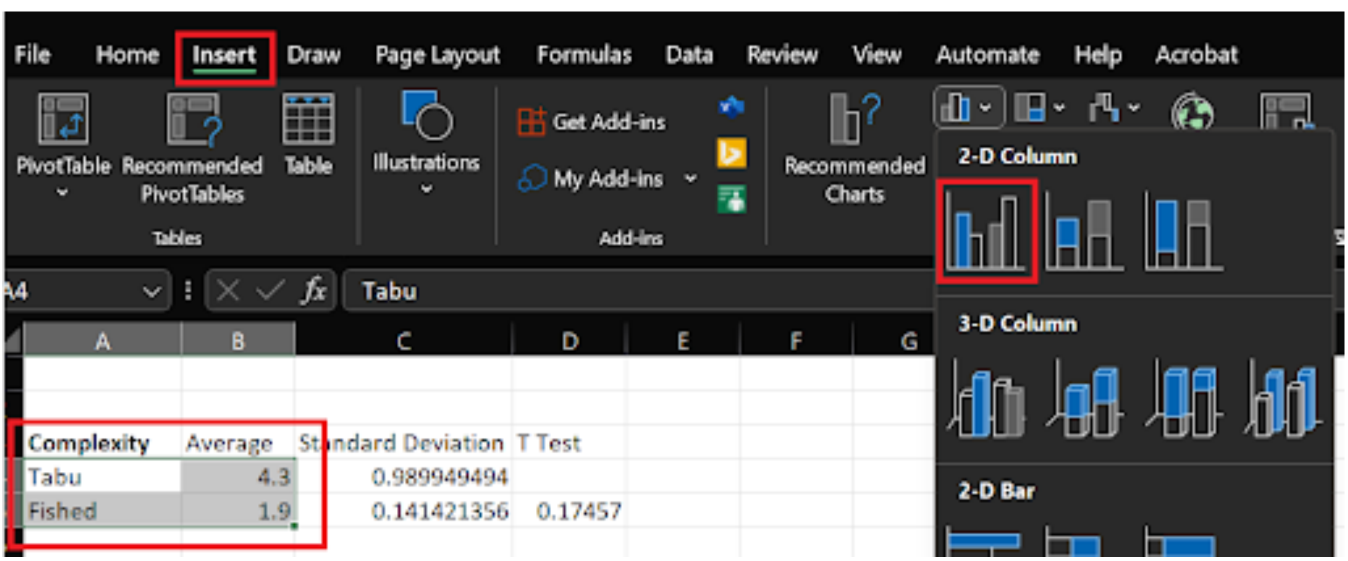
5. In the box for the standard deviation of complexity for *tabu* areas, calculate the standard deviation of the fields you used for the previous step. Type =STDEV.S(then highlight the complexity scores for *tabu* areas, and type) and hit enter.



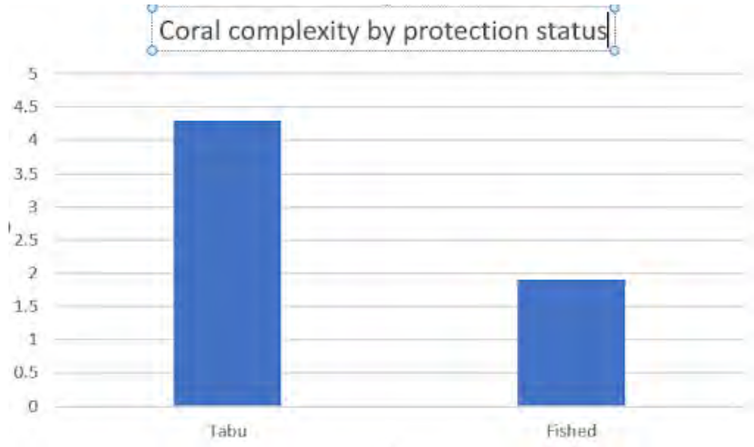
6. Repeat the previous two steps highlighting the complexity for the Fished videos to fill in the average and standard deviation for Fished areas.
7. Conduct a two-tailed T Test with unequal variance to compare the complexity of Fished versus *tabu* areas. Type =T.TEST(, highlight the *tabu* complexity values from Video Data (same as you highlighted for step 4), type comma ,, highlight the Fished complexity values from Video Data (same as you highlighted for Step 6), type comma ,, type 2, , type 3).



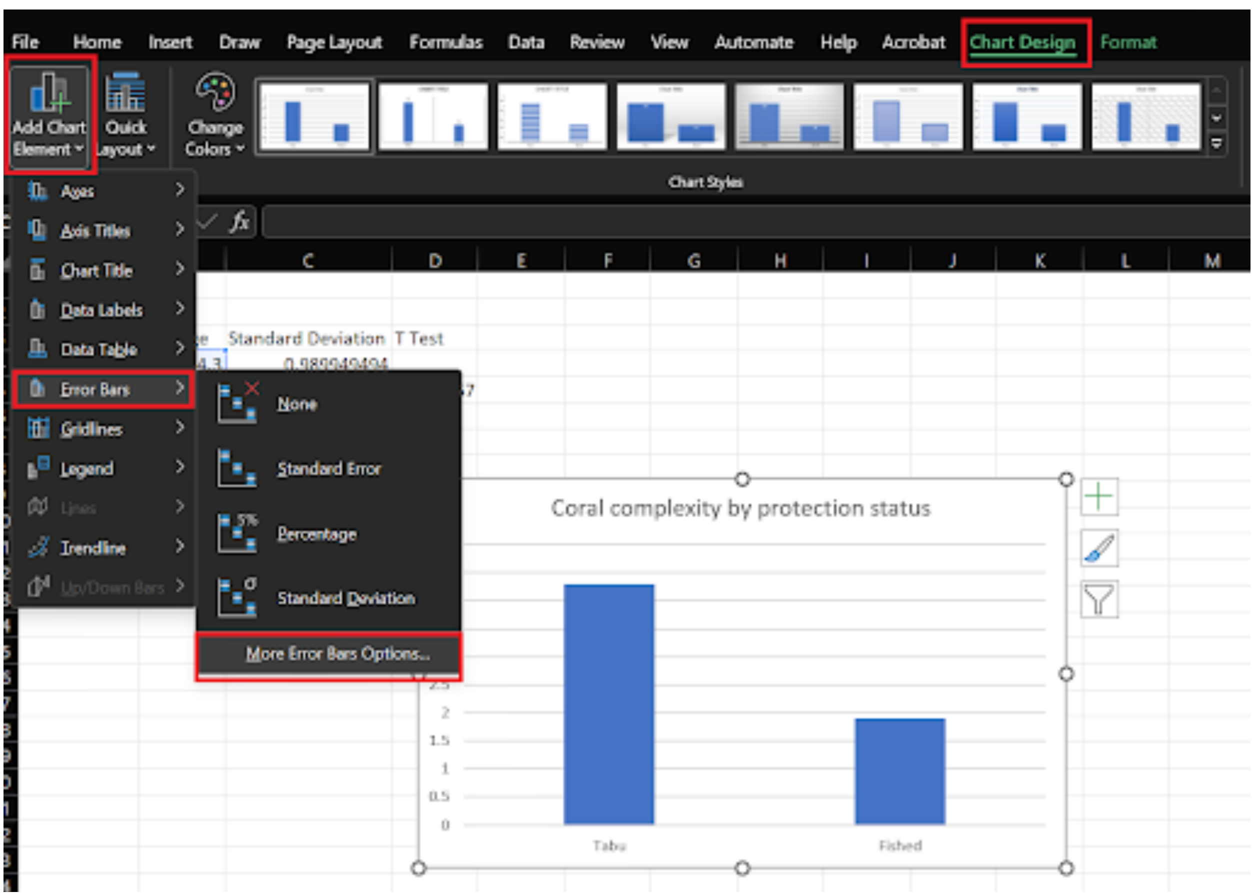
8. The number that the T test outputs is called a p value. It is the probability that the difference between the two averages is just by chance. As scientists, we say that if there is less than a 5% probability that the difference is by chance (meaning the p value is less than 0.05), the difference is statistically significant. For example, to write out the results for the example above, we would say: there is no significant difference in complexity between Fished (1.9+/-0.99) and *tabu* (4.3+/-0.14) areas (p=0.17). Example results sentences (replace the underlined green text with your own results):
    a. Fished areas (Average +/- Standard Deviation) have increased coral complexity compared to *tabu* areas (Average +/- Standard Deviation) (p=P VALUE)
    a. Fished areas (Average +/- Standard Deviation) have decreased coral complexity compared to *tabu* areas (Average +/- Standard Deviation) (p=P VALUE)
    a. There is no significant difference in coral complexity between Fished (Average +/- Standard Deviation) and *tabu* areas (Average +/- Standard Deviation) (p=P VALUE)
9. Generate a bar graph of your data. Highlight the protection status and average values > click Insert > 2-D Column > Clustered Column



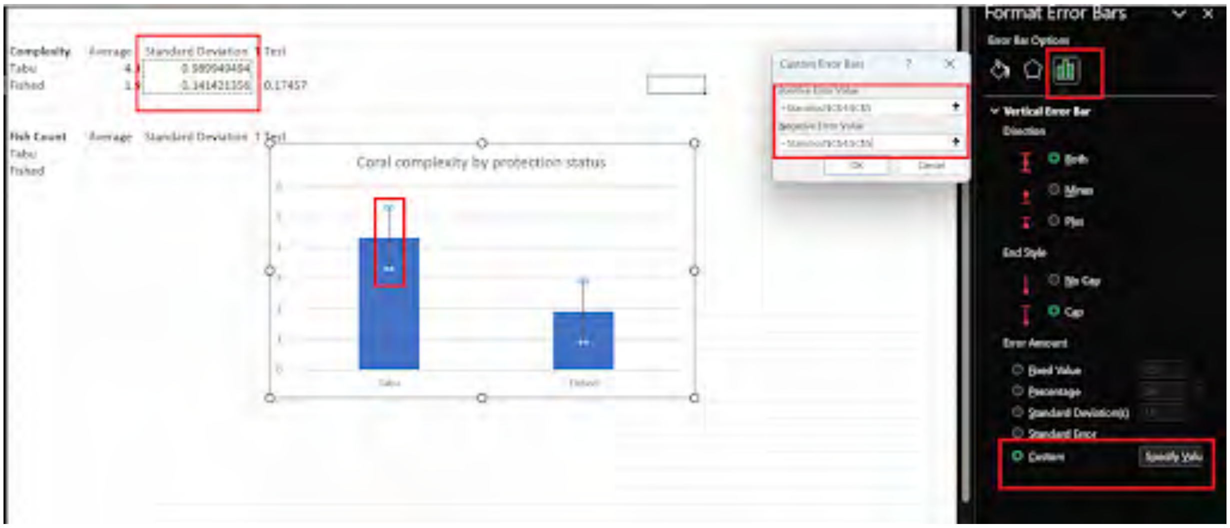
10. Change the Chart title by double clicking on it.



11. Insert error bars. With the chart selected, go to Chart Design > Add Chart Element > Error Bars > More Error Bars Options.



12. Set the Error Bars to the Standard Deviation you calculated: Double click on the Error Bars > Click the bars on the right menu > Select "Custom" at the bottom > Highlight the standard deviations for both "Positive Error Value" and "Negative Error Value".



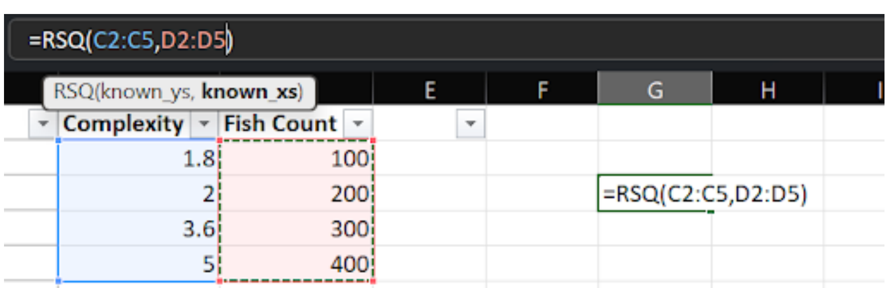
13. Play around with the colors, labels, and formatting to make the graph your own! Then, save a screenshot of the graph and of your data to a new document to be submitted to your instructor. In this document, also include an example results sentence with your results (Use the template from Step 8).

PART B. Test the hypothesis that *tabu* areas have different fish abundance compared to fished areas

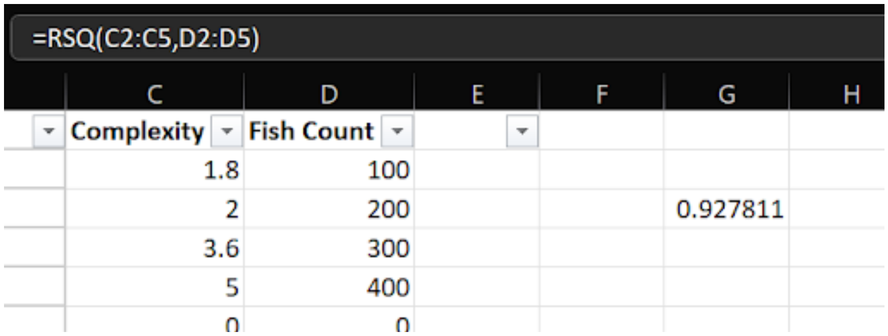
1. Use what you just learned in Part A to see if there is a difference in fish abundance between *tabu* and fished areas. Make a graph and fill in the table for fish count!
2. Save a screenshot of your graph and data, and write an example results sentence. Include these on your submission document.

PART C. Visualize the relationship between coral reef complexity and fish abundance

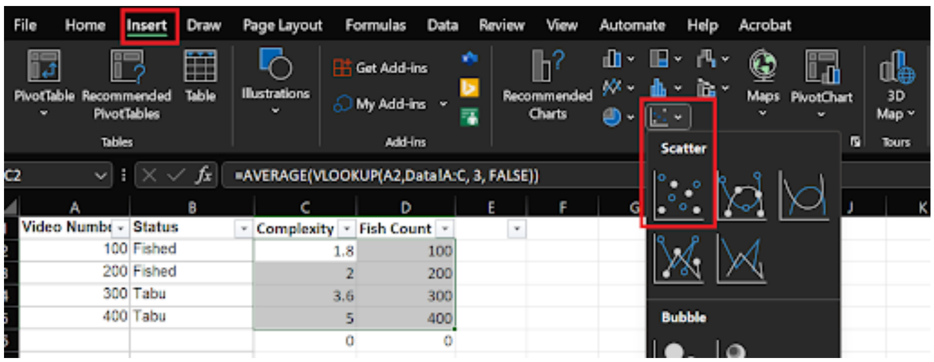
1. Calculate the relationship between fish abundance and coral complexity. We won't use a statistical test here, but will instead use an R-squared value[8]. This is a measure of how much of the variation in your variable is caused by the other variable. It can be between 0 and 1, meaning between none and 100 percent.
   a. In Excel, go to an open cell.
   b. Type =RSQ(, highlight the complexity data, type ,, highlight the fish count data, type) , hit enter.



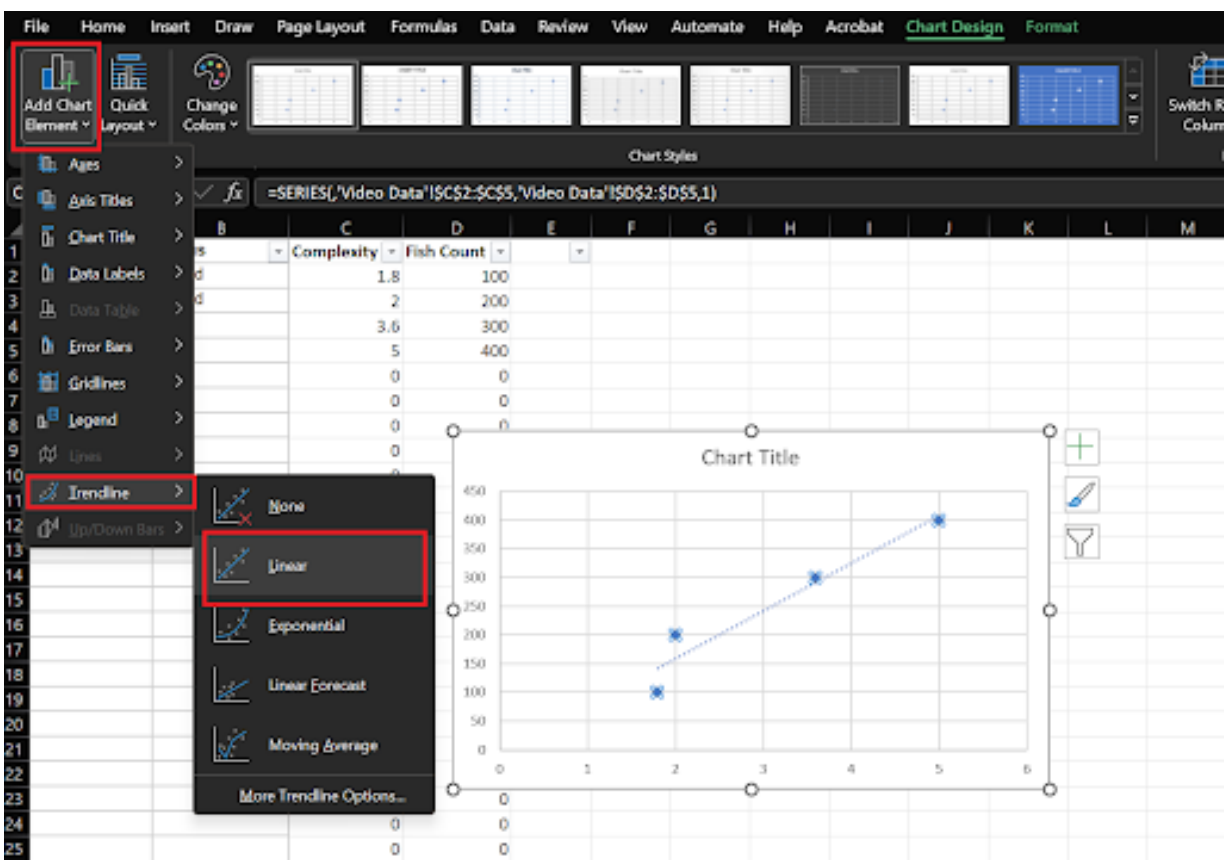
2. The number that is output is your R-squared. In this example, we would say that 92.8% of the variation in fish count is explained by complexity.



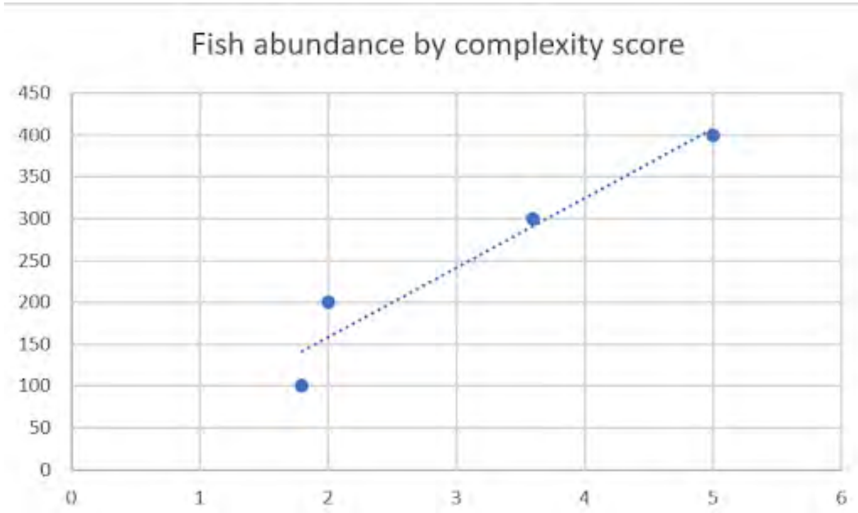
3. Highlight the fish count and complexity data from "Video Data".
4. Add a scatter plot. Choose Insert > Scatter > Scatter.



5. Add a trendline. Double click on the chart > Choose "Add Chart Element" > Trendline > Linear.



6. Change the graph title by double clicking.



7. Play around with the graph to make it your own!
8. Save a screenshot and add the screenshot to your document for submission. Submit the document, along with coral complexity and fish count, to your instructor.

ACTIVITY 3: CONSERVATION BIOLOGY MANUSCRIPT

Overview

After formulating your hypothesis and collecting data from Activity 1 and analyzing your data from Activity 2, the next steps are to reflect on your results and share your research findings in the form of a scientific manuscript. If your instructor assigns this as a group activity, please refer to instructions in Activity 4. The research you have conducted thus far is an example of the type of research that would be found in *Conservation Biology*.

Part A. Writing guideline for draft

- To submit: Complete manuscript draft, which will be graded.

To get an idea of the expectations for you as an author, read the Instruction Guide to Authors (provided by your instructor or downloaded from NCEP module collection at https://ncep.amnh.org) and use the checklist provided for each section.

1. Write the introduction

Describe the scientific question of interest. Start by describing the unknowns in this study and identify the population of interest that is being studied. Conclude the introduction section with your hypothesis statement(s) and predictions.
The introduction section of your manuscript should answer the following questions:
- Why is this study being conducted?
- Why is the study important?
- What is the aim of your study?
- What is your hypothesis/research question?

Journal format

Different research journals have different audiences, meaning the people who read your article will depend on the journal you choose. You will be drafting a research manuscript following the guidelines of *Conservation Biology*, a well-known peer reviewed journal that welcomes submissions that address the science and practice of conserving Earth's biological diversity. Manuscripts relevant to conservation that transcend the particular ecosystem, species, or situation described are prioritized for publication.

Grading format

Your manuscript will be graded by your instructor according to the *Conservation Biology* Manuscript Grading Rubric (Appendix 2). Each manuscript should resemble an article in *Conservation Biology* (headers, titles, author list and affiliations). You can submit the article as single spaced, double spaced or in 2 columns resembling a journal article (e.g., Lamb and Willis 2011; Kuempel et al. 2021). Follow your instructor's guidelines for submission. Note: your instructor may provide a manuscript template document.

2. Write the materials and methods

The materials and methods section should describe the study in detail so that it is replicable for any investigator. In this section you will answer the following questions:

- Where does the study take place?
- What is your study population?
- What methods were used to collect and review the data?
- What is the planned statistical analysis?

You should modify methods from (Goetze et al. 2019) to reflect how data was collected in this assignment.

3. Describe your results

Report your major findings in a systematic manner. This section should be organized such that the primary question of the study is addressed followed by the secondary research questions. Your results should be presented in an objective manner without overinterpretation. Use illustrations such as figures, tables, and graphs to showcase the results of your study. The illustrations should be mentioned in your text.

4. Discuss your findings

The discussion section is where you will interpret your data and draw conclusions. Start with a brief description of the main findings of the study answering the following questions:
- Do *tabu* areas (MPAs) have different coral reef fish abundance compared to fished areas?
- Do *tabu* areas (MPAs) have different coral reef complexity compared to fished areas?
- Is there a relationship between coral reef complexity and fish abundance?

The next step is to present your findings in scientific context. This is where you will be sharing what other investigators have observed, which can either support or refute your findings.

Following this, the next step is to discuss potential limitations to the study by answering the following questions:
- Think about the study design. Would there be a better way to test the impact of *tabu* areas on coral reef complexity and fish abundance? Hint: What if we could decide which areas were *tabu* areas and which were not?
- What are some benefits and limitations to the DOV methodology used in this study?
- In this study we used only one left camera and we did not use any special software since we were not measuring fish length or behavior. Given this methodology limitation, what modifications to your methodology would you propose?
- What are some confounding and uncontrolled variables that may be present in this study?

To end your discussion section, you will write one to two conclusion sentences about the study. Finally, you will write a few sentences about what next steps can continue this line of research.

5. References

The reference section should be up to date with the latest publications related to your line of research. It is recommended that you use a reference manager (e.g., Mendeley, Zotero, Papers, or others).

6. Writing the abstract

Word Count: Should not exceed 300 words.
The Abstract should summarize the Introduction, Methods, Results, and Discussion in that order. Key points should be identifiable however, do not make conclusions that are not supported by evidence reported in the abstract.

ACTIVITY 4: WORKING IN COLLABORATIVE TEAMS ASSESSMENT

Overview

Working as teams is an extremely important part of scientific research, particularly when working internationally on peer-reviewed manuscripts. If your instructor assigns Activity 3 as a group assignment, fill out and submit the Team Evaluation Form (Appendix 3).

Activity 4 is a Working in Collaborative Teams Assessment worth 25 points where you evaluate the contributions of each team member—you should review the information associated with that Activity so you are prepared to answer the questions and meet team expectations. The form includes Part A to be completed before beginning the manuscript and Parts B and C to complete after writing the manuscript.

Part A. Decide and agree upon roles for each team member. One way to divide the manuscript is to have each section assigned a "leader" and all other team members as "reviewers." Also, as a group, decide on a timeline for when you will have components completed and the final draft submitted.

Part B. Write the name of each group member in a separate column. For each group member, indicate the degree to which you agree with the statements under "Evaluation Criteria" using the following scale and total the number in each column: 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree

Part C. Feedback (please use full sentences and provide thoughtful responses):
1. Reflect about how effectively your group worked.
2. Identify any problems or disputes that occurred during your interactions and how were they solved or alleviated?
3. Did making a group plan and timeline have a positive effect on your learning and your manuscript assignment?

You will be graded as follows:
- Submission of the peer evaluation form with Part B and C completed in full (5 points),
- Average score from your team evaluators in Part C (20 points).

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GLOSSARY

1. Anthropogenic: caused by human activity
2. Keystone species: a species upon which the structure, functioning or productivity of a habitat or ecosystem depends (for example: coral in a coral reef)
3. Marine protected areas: areas of the marine environment protected by various strategies, such as closures, management, or scientific study
4. *Tabu*: a community-based management strategy in Fiji where fishing is prohibited; named for the customary closure of a fishing ground following a local Chief's death
5. Diver operated videos (DOVs): videos collected by divers along a transect that are later analyzed to provide data about the area
6. Transect: a predefined path that a scientist will follow to collect data
7. T-test: a statistical test used to determine whether there is a difference between two groups of data
8. R-squared value: a measure of how well the variation in one set of data can explain another set of data

NCEP materials are meant to be modifiable for each educator's specific classroom or training needs; adaptable Microsoft Word versions of modules are available for download through the NCEP module collection at https://ncep.amnh.org along with any available accompanying data files, appendices, presentations, teaching notes, and exercise solutions.

APPENDIX 1. STATISTICAL ANALYSIS SUBMISSION TEMPLATE

Name:

Part A. Is protection status related to coral reef complexity?

	Average	**Standard Deviation**
Tabu		
Fished		

P value:

Example results sentence:

Attach your graph.

Part B. Is protection status related to fish count?

	Average	**Standard Deviation**
Tabu		
Fished		

P value:

Example results sentence:

Attach your graph.

Part C. Is there a relationship between fish count and coral complexity?

P value:

Example results sentence:

Attach your graph.

APPENDIX 2. CONSERVATION BIOLOGY MANUSCRIPT GRADING RUBRIC

Criteria	Mastery	Proficient	Needs Improvement	Unsatisfactory
Title *Up to 5 points*	• Concise, specific, informative. • *5 points*	• Specific, but too wordy or jargon. • *4 points*	• Much too vague and/ or wordy. • *3 points*	• No title. • *0 points*
Abstract *Up to 7 points*	• Background/ big picture in 1-2 sentences. • Clear statement of question and/ or hypothesis. • Brief methods (2-3 sentences). • Major findings in no more than 2 or 3 sentences. • Concluding sentence related to statement of specific question or hypotheses. • *7 points*	• Background is too long. • Question and/or hypothesis are not clear. • Methods are excessive. • Too much detail about results. • Conclusion is vague. • *5 points*	• At least one element missing and the remainder are unclear. • Inadequate background. • No question or hypothesis. • Inadequate methods. • Not enough detail about results. • No conclusion. • *3 points*	• Multiple elements are missing. • *1 point*
Introduction Rationale of study *Up to 5 points*	• Justifies research in a compelling way to an audience of peers. • Demonstrates understanding of significance of the work. • Follows a clear, logical progression. • From what is known to what isn't known (i.e. "funnel shaped"). • Defines jargon and acronyms. • *5 points*	• Justification is too narrow or not geared to appropriate audience. • Logic occasionally is not clear or seems unorganized. • Student misunderstands some components of the work. • Some jargon and acronyms are not defined. • *4 points*	• Justification is too vague. • Significance of research is not demonstrated. • Logic is consistently unclear. • Most jargon and acronyms are not defined. • *3 points*	• Justification and significance are missing. • Logic is severely flawed. • Background is not appropriate for peers. • *2 points*
Introduction Questions, hypotheses, + predictions *Up to 7 points*	• Research question clearly stated and leads logically to hypothesis. • Hypotheses are clearly stated. • All variables that are part of the hypotheses are explained. • *7 points*	• Research question unclear or not sufficiently linked to hypotheses. • Hypotheses are present, but not in a logical place. • One of the variables that is part of the hypotheses is not discussed. • Irrelevant variable is introduced. • *5 points*	• Research question incorrectly posed or missing entirely. • Hypotheses are too vague. • More than one variable from the hypotheses is not discussed. • Multiple irrelevant variables are introduced. • *3 points*	• No research question. • No hypotheses. • Variables of interest are not discussed. • *1 point*

Materials and Methods Study system + location *Up to 5 points*	• Correctly describes study location, context, system. • *5 points*	• Too much or not enough detail provided. • Minor errors in details provided. • *4 points*	• Important details are absent. • *2 points*	• Does not include description of study location or system. • *0 points*
Materials and Methods Field and laboratory protocols used *Up to 5 points*	• Provides sufficient information for reader to repeat the work. • Clearly describes experimental design and sampling procedures with justification in relation to questions/ hypotheses/ predictions. • *5 points*	• Too much or not enough detail is provided. • Experimental design and sampling procedures are described but unclear and/or are not justified in relation to questions/hypotheses/ predictions. • *4 points*	• Excessive detail about experimental design and methods. • Design and methods not justified. • *2 points*	• Described methods are inaccurate and show a misunderstanding of the project. • No mention of experimental design. • *1 point*
Materials and Methods Data analysis *Up to 5 points*	• Graphing methods are appropriate to address the hypotheses posed and graphs are presented accurately. • *5 points*	• Graphing methods chosen are not ideal to address the hypotheses posed and/or graphs are presented with some inaccuracies. • *4 points*	• Graphing methods are not well-connected to hypotheses posed and are inaccurate. • *2 points*	• Graphing methods are not presented. • *0 points*
Results Description *Up to 7 points*	• Concisely and correctly summarizes all results. • Results statements are supported with reference to data and/ or statistics. • Results effectively address questions/ hypotheses posed. • Includes no in-depth analysis. • *7 points*	• Concisely and correctly summarizes most results. • Some results are unclear or unrelated to questions/ hypotheses posed. • Data are not used to support general statements. • Includes too much analysis/discussion. • *5 points*	• Some results are missing entirely and/ or results are mostly unclear. • Statements are not supported by data. • Includes frequent statements that should be in discussion. • *3 points*	• Results are not adequately explained or presented. • Results are unrelated to questions/ hypotheses. • More than half of the text belongs in the discussion. • *1 point*
Results Figures or Tables *Up to 7 points*	• Each figure/table makes an important contribution. • Figures/tables illustrate data correctly and with error bars. • Figures/tables have complete captions/legends and are formatted appropriately. • *7 points*	• Unnecessary table or figure. • Figures/tables may lack properly calculated error bars. • Figure captions/ legends are incomplete. • Occasional formatting errors. • *5 points*	• A necessary table or figure is missing entirely. • Data is presented inaccurately. • Many captions/ legends are incomplete. • Frequent formatting errors. • *3 points*	• Multiple figures or tables are missing. • Inadequate figures. • *1 point*

Discussion Introduction + data interpretation *Up to 5 points*	• Briefly restates the results within the context of the study. • Describes whether and how data support the hypothesis. • Effectively links findings to the research question/ objective. • Addresses unexpected anomalous results with specific ideas (not speculation). • *5 points*	• Restates too much detail from the results or does not interpret results clearly. • Whether the data supports the hypothesis is not clear. • Only partially links results to question/ objective. • Unexpected result is addressed with speculation. • *4 points*	• Restatement of results is too vague or has some misinterpretation. • The results are not linked to the hypothesis or research questions. • Interpretation of findings is weak or missing. • *3 points*	• No restatement of results. • Inadequate discussion of findings. • *2 points*
Discussion Main body *Up to 7 points*	• Interprets results in the context of primary literature. • Utilizes topic sentences to effectively structure discussion. • Effectively references results in relation to paragraph content and topic sentence thesis. • Explains similarities and differences to published results. • Accurately presents conservation theory in the interpretation of results. • *7 points*	• Some results are not discussed relative to primary literature. • Topic sentences are not wholly related to content within paragraphs. • Explains results without relation to topic sentence thesis. • Limitations of study or explanations of some findings are missing. • Conservation theory is presented but not related to results. • *5 points*	• More than one result is not discussed relative to primary literature. • Results are summarized but without interpretation and explanation. • Topic sentences are missing. • Explanations for several findings are missing. • Conservation theory is misrepresented. • *3 points*	• Results were not discussed relative to the primary literature. • Topic sentences are missing. • Conservation theory is absent. • *1 point*
References *Up to 15 points*	• Citations are appropriate and well chosen, showing adequate background research on the topic. • Citations are provided for background, justification, and any specific methods or claims. Correct formatting of citations within the text and literature cited section. • 5+ primary sources used. Zotero (or other reference manager) used properly. • *15 points*	• Some references are not relevant. • Some sections are missing references. • A couple of formatting issues. • A few references are not primary literature. • Incorrect reference format used. • *12 points*	• Several references are not relevant. • Frequent formatting issues. • Fewer than 5 references are included. • Zotero (or other reference manager) not used. • *8 points*	• Lack of relevant references. • *5 points*

Formatting *Up to 5 points*	• Appropriate length and structure for scientific manuscript. • Details are apportioned properly among the paper sections, which occur in the correct order. • 2-4 Figures and/or Tables presented. • *5 points*	• Paper is too short or too long. • Has some details placed in the wrong sections. • Sections are presented out of order. • Only 1 Figure or Table is presented. • *4 points*	• Paper is much too short or too long. • Completely missing a section. • *3 points*	• Paper does not follow formatting guidelines. • *2 points*
Readability *Up to 15 points*	• Writing is compelling and at an appropriate level. • Paper is organized around detailed topic sentences that provide a clear outline of the paper. • Contains few or no inaccurate statements. • Language is precise and scientific. • Writing is relatively free of grammar errors and typos. • *15 points*	• Writing is of high quality but at times vague or disorganized. • Some topic sentences are weak and/or do not forecast the paragraph contents. • A couple of inaccurate statements. • Occasional overuse of passive tense or jargon. • Occasional grammar errors and typos. • *12 points*	• Writing is frequently unclear or unscientific. • Paper is not organized around topic sentences. • Several inaccurate statements. • Language and grammar occasionally impede comprehension. • *8 points*	• Writing is mostly unclear. • Multiple inaccurate statements. • Much of the writing is difficult to understand because of grammar issues. • *5 points*

APPENDIX 3. CONSERVATION BIOLOGY MANUSCRIPT TEAM EVALUATION FORM

Part A. Prior to beginning the manuscript, agree upon roles for each team member. Write them here.

Group Member 1: ____________________

Group Member 2: ____________________

Group Member 3: ____________________

Group Member 4: ____________________

Part B. Write the name of each group member in a separate column. For each group member, indicate the degree to which you agree with the statements under *Evaluation Criteria* using the following scale and total the number in each column:

1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree

Evaluation Criteria	**Example** AB Smith	**Group Member 1**	**Group Member 2**	**Group Member 3**	**Group Member 4**
Contributes meaningfully to group discussions	Score 1 - 4				
Completes group assignments on time	Score 1 - 4				
Prepares work in a quality manner	Score 1 - 4				
Demonstrates cooperative and supportive attitude	Score 1 - 4				
Contributes overall to the success of the project	Score 1 - 4				
TOTAL (out of 20 points possible)					

Part C. Write out responses to the following prompts. Please use full sentences and provide thoughtful responses.

1. Reflect about how effectively your group worked.
2. Identify any problems or disputes that occurred during your interactions and how were they solved or alleviated?
3. Did making a group plan and timeline have a positive effect on your learning and your manuscript assignment?