Field Science Research Project Plan

This is a guide for teachers and students to prepare for LiMPETS and Watershed Guardians field research and to communicate findings through scientific posters and community action projects.

Contents

Overview of a Project

1. **Build Background Understanding** of the field sites you will be working in and the type of data you will collect. Understand why these community science measurements are important.
2. **Create a Research Question** that you could explore through the data you will be collecting in the field, as well as archived data from the LiMPETS and GLOBE databases.
3. **Design an Experiment** based on LiMPETS or Watershed Guardians research protocols.
4. **Choose Experimental Protocols** from standard protocols in LiMPETS of Globe
5. **Collect Data** in the field or from the LiMPETS, GLOBE, or other databases.
6. **Analyze Data** from the field and archived database data that is relevant to your question.
7. **Choose a Format to Communicate your Findings** through a scientific poster or a community action project.

Step 1: Build Background Understanding

LiMPETS Sandy Beach Monitoring

- Student resources on pacific mole crabs, methods for monitoring, and information on study sites https://limpets.org/sandy-beach-monitoring/student-resources-sandy-beach-monitoring/
- Teacher resources on LiMPETS Sandy Beach Monitoring (password: **abalone**) https://limpets.org/teacher-resources/teacher-portal/sandy-beach-resources/

LiMPETS Rocky Intertidal Monitoring

- Student resources on Rocky Intertidal Monitoring methods, species, and sites https://limpets.org/rocky-intertidal-monitoring/student-rim/
- Teacher resources on LiMPETS Rocky Intertidal Monitoring https://limpets.org/teacher-resources/teacher-portal/rocky-intertidal-resources/ (password: **abalone**)

Watershed Guardians

- Teacher resources on Watershed Guardians including background learning activities
    - Pre-trip in-class lessons
    - Crumpled Paper Watershed

    - River Runner – interactive watershed map https://river-runner.samlearner.com/
- GLOBE resources on Hydrosphere research methods are at https://www.globe.gov/web/hydrosphere
    - Introduction to the Hydrosphere (English) https://www.globe.gov/documents/11865/9d46bef9-31cc-4c50-83f9-6a64c90bc46f
    - Introduction to the Hydrosphere (Spanish) https://www.globe.gov/documents/10157/381040/hydro_chap_es.pdf

Step 2: Create a Research Question

To create a good research question, you need to identify the variables you are going to look at. The **independent variable** is a variable that you control or select for. The **dependent variable** changes in response to the independent variable. All other variables must be **controlled** or kept constant for a fair test. A good research question will ask, "what happens to the [*dependent variable*] as the [*independent variable*] changes?"

Here are some examples of variables you could look at and the experimental question that goes with each.

Table 1: Research Variable and Experimental Questions

	Independent Variable	**Dependent Variable**	**Controlled Variables**	**Experimental Question**
SBM	Season	Size of sand crabs	Beach, location on the beach, level of the tide...	Does the size of sand crabs vary with the season?
SBM	Location	Number of sand crabs	Season, number of samples compared, tide...	Are there more sand crabs in Monterey beaches than in Santa Cruz beaches? Are there more crabs at Marine Protected Area beaches than non-MPA beaches?
RIM	Tidal zone	Number of giant anemones	Site, season, tide, ...	Are there more anemones in the splash zone than the surf zone?
RIM	Density of mussels	Amount of kelp	Season, number of samples compared...	Does the amount of kelp go down if the number of mussels goes up?
RIM	Time	Number of sea stars	Location, season...	How has the number of sea stars changed in the years since sea star wasting disease became prevalent?
WG	Flow rate	Turbidity	Site, season, ...	Does the turbidity increase as flow rate of a stream increases?
WG	Location	Nitrate	Sampling method, season...	Does the concentration of nitrate increase downstream?

Table 2: Possible variables to investigate

LiMPETS – SBM	LiMPETS – RIM	Watershed Guardians
Crab size Number of crabs Number of recruits Number of adults Number with eggs Number of males Number of females Number per sample (density) Location in the transect Site Time of day Season Tide	Number of ____ (species) Density of ____ (number of squares it appears in) Location on transect Site Season Tide	*Water quality variables:* Temperature, dissolved oxygen, nitrate, flow rate, depth, conductivity, turbidity Location Upstream-downstream Season

Propose a Hypothesis for Your Research Question

A hypothesis is a possible answer to your research question based on observation, prior experience, or logic. It takes the form of:

“We think that... because...”

Table 3: Example Hypotheses

LiMPETS – SBM	LiMPETS – RIM	Watershed Guardians
"We predict that beaches within a Marine Protected Area will have more sand crabs because MPAs are supposed to protect ecosystems and biodiversity.”	"We think the number of sea stars has decreased over time because of sea star wasting disease.” “I believe I will find fewer limpets in areas with large number of mussels because mussels may crowd out limpets’ habitat.”	“I predict nitrate levels will be higher downstream of agriculture areas due to runoff of fertilizer.” “We think dissolved oxygen rates will be higher in water with faster flow rates because fast-moving water can put more atmospheric oxygen into the water.”

Step 3: Design an Experiment

Make a plan to collect data that will allow you to measure how your dependent variable responds to your independent variable while all other variables are controlled. You need to **minimize the uncertainty** that your dependent variable is changing in response to your

independent variable. You also need to collect enough data that you feel confident that your result is more **significant** than just a random occurrence. Scientists do this by carefully **controlling (keeping constant) all variables** except the independent and dependent variables and by making **replicate (repeated) measurements**.

Controlling Variables

Design your experiment so that you change the independent variable and you measure how the dependent variable responds. Everything else that might affect the experiment needs to be kept the same for the whole experiment. This is sometime called a "fair test."

- For example, if you look at the number of sand crabs you find in north-facing vs south-facing beaches, you will need to make sure that the level of the tide and the season and everything else stays the same. If you don't, you will not know what factor affected the number of sand crabs.

Table 1 gives an idea of some of the variables you would need to keep constant in the example experiments.

Replicate Measurements

If you only measure something once or twice, the result you get could just be a random occurrence. Scientists want to see many measurements showing the same result to be convinced that there is a significant – more than just a random – relationship between your variables.

- For example, if you measure the turbidity of a stream one day and see that it is much higher downstream from the bridge than upstream, it could be just a random occurrence. But if you measure the downstream turbidity to be higher on 3 different days, it seems likely that it is more than just a fluke.

Scientists typically make 3 replicate measurements for each comparison.

Table 4: Experimental Design Examples

	Independent Variable	**Dependent Variable**	**Controlled Variables**	**Experimental Question**
SBM	Season	Size of sand crabs	Beach, location on the beach, level of the tide...	Does the size of sand crabs vary with the season?
Experimental Design: Collect sand crabs on 3 different transects on Seabright Beach in September and do the same thing in May. Compare the average size of the sand crabs on the 2 different dates.				
RIM	Density of mussels	Amount of kelp	Season, number of samples compared...	Does the amount of kelp go down if the number of mussels goes up?
Experimental Design: Look at 3 quadrats on the transect and compare the number of squares that have kelp and the number that have mussels.				

WG	Flow rate	Turbidity	Site, season...	Does the turbidity increase as flow rate of a stream increases?
Experimental Design: Choose 3 sites on the stream and measure flow rate and turbidity at each site.				

Quantifying Variability (high school topic)

Collecting replicate measurements can also allow you to calculate the variability in your data. You can average the measurements to get the mean value and you can calculate the standard deviation to quantify the variability in the data.

- For example, you are comparing the temperature in 2 different streams on the same day at the same time and you get the following data:

Stream	**Stream A**	**Stream B**
Measurement 1	16.0 °C	18.2 °C
Measurement 2	16.3 °C	19.8 °C
Measurement 3	15.5 °C	15.4 °C
Average	16.3 °C	17.8 °C
Standard Deviation	0.3	2.2

If you just look at the average values for the 2 streams, you would say that the water in stream B is warmer than the water in stream A. However, the standard deviation for the water in stream B is much higher than that for stream A. This means that the measurements are very different from each other – there is more uncertainty in the data. Given the level of uncertainty, we can't be confident that the measurement in stream B is really higher than the measurement in stream A.

For more information on using statistics to represent your data, look at

https://datanuggets.org/

https://concord.org/

https://tuvalabs.com/

https://nces.ed.gov/nceskids/

Step 4: Choose the Experimental Protocols

An **experimental protocol** is the set of steps you follow to make a measurement. Both LiMPETS and Watershed Guardians have very specific protocols. That allows us to compare

data collected by anyone using these methods in any location. Here is where you can find the standard protocols

LiMPETS Rocky Intertidal https://limpets.org/rocky-intertidal-monitoring/ri-methods/

LiMPETS Sandy Beach https://limpets.org/sandy-beach-monitoring/sb-methods/

Watershed Guardians https://www.pgmuseum.org/watershed-guardians

Step 5: Collect Data

You will either collect data on your LiMPETS or Watershed Guardians field trip, or you can access data from the LiMPETS or GLOBE (for Watershed Guardians) databases.

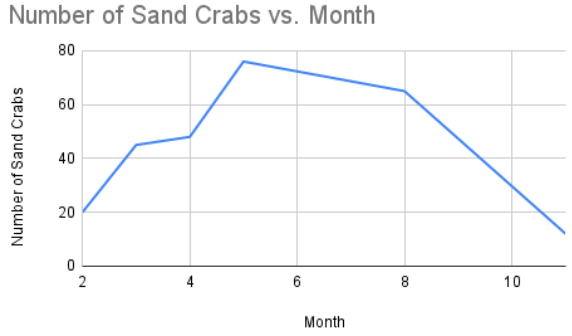
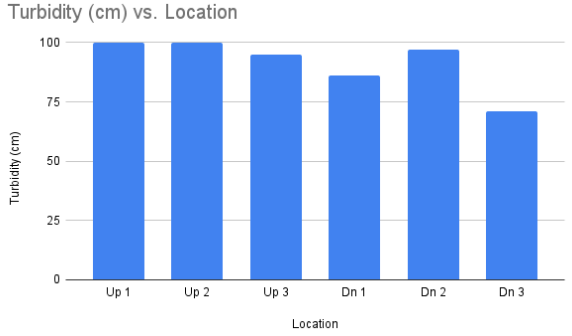
LiMPETS Roky Intertidal Data https://rockyintertidal.limpets.org/app/data/

LiMPETS Sandy Shore Data https://sandybeach.limpets.org/app/

Watershed Guardians Data https://www.globe.gov/globe-data/globe-data-user-guide

Step 6: Analyze Data

Once you have collected data from the field or database, you can analyze it to see if it supports or does not support the hypothesis you made. Creating a graphical display of the data can sometimes help you see patterns. The statistics websites at the end of Step 3 above can help you decide what kind of graph is the best one to use for your data. Examples include line graphs and bar graphs.

Line Graphs – for continuous data	**Bar Graphs – for discrete data**
Does the size of sand crabs vary with the month of the year?	Is the turbidity of the water higher upstream of the bridge or downstream?
Independent – month (1=Jan, 2=Feb...) *Dependent* – number of sand crabs	*Independent* – Location (up or down) *Dependent* – Turbidity
	

Use the CER Model to make a statement about what your data show.

EXAMPLE

> **Claim** – Our data supports our hypothesis that the number of sand crabs is higher in the summer months than in the winter months.
>
> **Evidence** – The average number of sand crabs in May, June, July, August was 51. While the average in November, December, January was 22
>
> **Reasoning** – This leads us to conclude that the number of sand crabs is affected by the season.

Your analysis should also indicate the strength of the data. This can be done qualitatively (no numbers) by discussing quality assurance practices, like making sure all of the team members were trained on the protocol and making sure all of the tools were calibrated. The strength of the data can be shown quantitatively (with numbers) using a statistic like the standard deviation or standard error.

Step 7: Communicate Your Findings

Students can enter traditional **research posters** – like science fair projects, or **conservation action projects** in the Student Research Symposium.

Research Poster

A research poster is a standard format for communicating your research question, how you collected data, and what you found. This format is used all over the world from elementary students doing science fair projects to famous scientists communicating their work at research meetings.

Find an editable example of a research poster with sentence-starters here: https://docs.google.com/presentation/d/1Hmu4qaoeOgu-MxNpD62o87BBye-UDMCNrUCWuf4Z3ms/copy#slide=id.p1

Conservation Action Project

A conservation action project is a project you do in your community using the data you collected to take action and make an impact on the environment. Examples of projects could be

- Creating a field guide with information based on data you collected
- Writing a letter to the editor with evidence from your data that encourages people to pick up pet waste in trails in the park so that it does not contaminate the water way
- Speaking at a town council meeting about why native grasses should be planted to catch debris before it enters the ocean

In each of these examples, there is a particular **audience**, a behavior or **change** encouraged, and **data** to support why this change needs to occur.

Coming Soon! . . . An editable example of a poster to communicate a conservation action project.

We look forward to seeing your work at the Student Research Symposium