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Marine Protected Area Program Model

CALIFORNIA
MARINE
PROTECTED
AREAS

Land Acknowledgment

The place that we call Crystal Cove State Park today is located on the traditional and unceded lands and waters of the Acjachemen and Tongva Tribal Nations.

We recognize that we are deeply indebted to these Tribal Nations, and together, we are committed to uplifting the voices of everyone working to protect this special place.

Credits

This project was made possible through a 2020 grant from the Ocean Protection Council and Coastal Quest's MPA Outreach & Education Small Grants program.

Coastal Quest administers the Marine Protected Area (MPA) Outreach and Education Small Grants Program. This competitive grant program, funded by the Ocean Protection Council and private donors, provides support to organizations serving many priority communities to increase MPA stewardship, engagement, compliance, and leadership.

For more information on Coastal Quest and the MPA Small Grants Program, visit their website (*www.coastal-quest.org*).

Crystal Cove Conservancy

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Introduction

Are you ready to immerse students in a community science education program in your local MPA?

Since 2012, Crystal Cove Conservancy has worked with California State Parks, UC Irvine, local schools, and other partners to refine the educational approach for our Marine Science Cruise. This innovative program puts middle school and high school programs on the sea to work alongside university researchers and natural resource managers to monitor changes in the Crystal Cove State Marine Conservation Area. Learning evaluations have shown that as students take part and collect data, our program model helps them develop a deeper understanding of environmental systems.

This guide is part of our efforts to share our model for learning with other community science and environmental education organizations so that you, too, can design effective programs for learners!

What You Will Do

Whether you're an educator who wants to get students involved in protecting your local MPA or a community science project manager looking to help students learn, this is the guide for you!

In this guide, we'll share our model for developing community science education programs based in MPAs. We'll walk you through the steps of assessing needs, developing partnerships, planning your program, and developing educational sessions for students. By the end, you'll understand what it takes to develop a similar community science educational program based in your own MPA!

By the end of this guide, you will be able to...

- Describe our model for community science education.
- Describe the steps to design your own community science educational program in a local MPA.

Who We Are

Crystal Cove Conservancy is the nonprofit public benefit partner to Crystal Cove State Park, which is located on the traditional lands and waters of the Acjachemen and Tongva Tribal Nations in Orange County, California. Together with our State Park partners, we support important preservation, education, and conservation initiatives to cultivate our planet's next generation of environmental stewards ensuring that Crystal Cove, and places like it, live on for generations.

Since 2012, we've partnered with Crystal Cove State Park, UC Irvine, and other schools and organizations to develop and refine an educational model to engage students in real-world learning. During our community science programs, students take part in real scientific investigations, working alongside researchers and land managers to investigate challenges faced by Crystal Cove State Park.

Student findings inform real natural resource management decisions, and past student data has even been included in ***academic publications***, furthering our understanding of how best to protect our ocean and public lands.

Our Approach to Learning

Our community science education programs are anchored in the idea of science-as-practice: that the best way to learn science is to do science. Community science programs are an excellent way to give students a science-as-practice experience, and this approach means that students will really be helping to advance scientific knowledge as they participate in our programs. The research that they take part in is real, addressing real questions from scientists and land managers. Every year, we go into our program season unsure of what they'll find.

We also ground our work in sociocultural approaches to learning. We believe that people learn best by engaging in conversation with each other. Explaining reasoning out loud, asking questions of our peers, and responding to critique allows us to develop and test our ideas about how the world works. It also mirrors how professional scientists work by engaging in discussion and challenging ideas together. This approach to learning is why we have students work in research teams and build in time for discussions and reflection into every session.

Finally, we believe strongly in an assets-based approach to environmental education. Through programs like the MPA Exploration, we aim to empower youth so that they know that they can make a meaningful contribution to conservation. We also recognize that all learners are natural scientists who possess an innate curiosity about the world. When students take part in the MPA Exploration, they are not learning to do science from scratch, but are practicing and refining the scientific skills that they already possess.

What is Community Science?

Also known as citizen science or participatory science, community science projects allow participants to take part in real research projects as they help to collect, contribute, and/or analyze data.

Community science projects can be designed in a variety of ways. In some cases, non-professional scientists collect or analyze data for an established research project. In others, they co-create the project with professional scientists or they may create the project on their own and bring in professional scientists when necessary. In the case of our MPA Cruise program, students act as community scientists as they collect and report data for scientific monitoring projects that have already been established.

In recent years, some organizations have moved away from using "citizen science" in favor of the more inclusive "community science." Two organizations have published why they made the change to using community science: ***Natural History Museum of Los Angeles County*** and ***Audubon***. Although we use the term "community science" in this guide, some organizations and universities use participatory science instead to distinguish their projects from true community science projects that are led by community members. You can decide which term is the best fit for your project based on your stakeholders and your project goals.

Who You Are

This guide is intended both for community science practitioners who already have an MPA-related research project in mind and for educators who are interested in connecting existing educational partnerships to real-world research.

Since there are a lot of great resources out there already for developing community science projects, we'll link to those where possible.

As you read through this first document, you'll have a chance to consider whether our approach to learning will work for your organization. Before you get started, you may want to consider the following questions internally so that you can decide whether our model will work for you.

- Do you have a research or monitoring project already in mind? Do you have ideas for possible researchers or resource manager partners that you could work with?
- What monitoring or research question might you address? What are your data needs?
- Why are you interested in designing a community science education program? What do you hope to achieve?
- Do you have staff resources or funding to commit to program development?
- What experience do you or your team have with designing educational programs? If you don't have direct experience, do you have partners who might?
- What big learning goals do you want students (or other participants) to get out of taking part in your community science program?

Our Story: The Marine Protected Area Science Exploration

In June 2012, a new MPA network for California's South Coast region was implemented. This included the establishment of the Crystal Cove State Marine Conservation Area (SMCA), the underwater offshoot of Crystal Cove State Park. However, at the time, there was no funding and no guidance on how the State Park should monitor the newly-established Crystal Cove SMCA to determine whether it was working or not.

That was how the Crystal Cove MPA Cruise was born. Crystal Cove Conservancy, the park's nonprofit partner, entered into a new partnership with Newport Landing Sportfishing, a nearby fishing company. At the time, the partnership was particularly notable because environmentalists and the fishing industry had been at loggerheads for so long during the MPA implementation process. The Conservancy then partnered with Crystal Cove State Park's natural resource managers and UC Irvine researchers to set up a series of monitoring projects, which we continue to this day.

As the new program grew, we heard from many teachers that the MPA Cruise program had a real impact on their students. Students loved contributing to real environmental monitoring projects, and many reported back to their teachers that they decided to major in environmental or marine science after taking part in the program. However, as we began to work with our partners at UC Irvine to assess what students were learning, we quickly realized that the field trip alone was not enough to introduce students to the skills that professional scientists use. We also heard from teachers that they struggled to integrate science practices like modeling or data analysis into their classroom and needed additional supports.

To address these needs, we began working with our partners at UC Irvine to explore how best to design an educational program around our data collection projects. Our design-based research approach to solving this problem took place over several years and spanned several different programs. Over time, we've been able to refine an approach to community science education programs that immerses students in the full process of science, from asking questions and designing a model to analyzing data and sharing their findings.

The MPA Cruise program has grown and evolved since its original creation. Today, in its final format as the MPA Science Exploration, it includes ten different sessions and an optional boat field trip.

You can view the current version of ***the MPA Science Exploration program*** on our website to get a sense of what a fully-fleshed out educational program might become.

Our Model for Community Science Education Programs

When we begin designing a new community science education program, we use six different sessions that make up the student experience. This learning sequence is intended to mirror how professional scientists work, guiding students through the process of asking questions, designing a model, refining that model, collecting data, analyzing their data, and sharing their findings.

Session	Overview
1 Asking Questions	Students explore the local MPA, generate questions about its ecosystem, and reflect on how they might help protect it. They are also introduced to the community science research project that they'll take part in.
2 Building a Model	Students work in research teams to develop a model of the ecosystem.
3 Background Research	After identifying any questions about their model, students take part in background investigations to learn more.
4 Collecting Data	Research teams visit the MPA to collect data for their research project.
5 Analyzing Data	Research teams create visualizations to look for patterns in their data, and then use those visualizations as evidence to support a claim about their research question.
6 Sharing Our Findings	Research teams design a presentation to share their findings with community members or other stakeholders.

This model aligns with state learning goals for students of all ages, as detailed in the Next Generation Science Standards. (More on those in a bit.) It also follows best practices in science education by giving students a chance to make sense of real-world phenomena while working with messy real-world data.

A lot about our program model is intended to be flexible. In our programs, some of these sessions take place in the field, where students have a chance to visit the Crystal Cove SMCA and ask questions, make observations, and collect data. Others take place at students' schools, where teachers walk participants through designing a model or analyzing data. We've also found it easy to adapt the model for different age groups of learners. Depending on the time that schools have available, some of the six sessions may also be broken down into multiple class meetings.

Is Community Science the Right Approach for Your Organization?

A community science approach is a great way to engage students in authentic science experiences within Marine Protected Areas, but you need to make sure that the approach aligns with your goals and with the goals of your partners. In some cases, a research project isn't a good fit for bringing students in.

Community science with students works well under certain circumstances, including the following:

- It is possible for students to safely access the site where the research takes place without harming the natural resources there.
- You have research and natural resource management partners who are willing to work with you to adapt data collection protocols for students so that they can effectively contribute to data collection.
- The project would benefit from community knowledge of the place, animal, or plant that is being studied.
- STEM learning and engaging students in real-world science experiences are a top priority for your organization.

Community science with students does not work well in certain circumstances, including the following:

- The research project takes place at a marine site that is dangerous or difficult to access.
- The necessary training is extensive and requires the use of expensive or highly technical equipment.
- The protocols are too complicated for students to collect reliable and valid data.
- The research project is the top priority for your organization and you would not be able to make modifications to involve students.

As you're deciding whether community science is the right approach for your organization, the following publications may also be helpful:

- ***Forest Service Citizen Science Project Planning Guide*** - This guide includes a section that will help you think through whether a community science approach is a good fit for you. Their ***Forest Service Citizen Science Toolkit*** also includes a comprehensive project plan template that includes a helpful template for a budget.
- ***Planning Your Community-based Citizen Science Monitoring Project for Dam Removal and Watershed Restoration*** - The Center for Community and Citizen Science at UC Davis wrote this guide. While it is focused on Dam Removal and Watershed Restoration, it has information that would be helpful for thinking through whether a community science approach is a good fit for you.

What You'll Need to Get Started

Designing a community science educational program can be more resource-heavy and require more time than simply inviting students out on a field trip -- but it also has more benefits. Scaffolding learning experiences so that students can take part in developing a model, analyzing data, and sharing their findings meets school learning goals and allows them to develop a much deeper understanding of the ecosystem in your local MPA, as well as exposing students to how science is really practiced.

Although you don't need to have all of these in place before you begin planning your project, developing or securing the following partnerships and other items will help ensure your success:

- A partnership with a resource management agency, such as a local state park or county beach, who can help identify real-world questions to answer.
- A partnership with a researcher, who can help support the design of the community science monitoring project.
- A partnership with a teacher, school, youth group, or other community group who will take part in the program (and hopefully give input on its design).
- Connections with the local Tribal community, who can help inform you of the best way to incorporate their ideas and perspectives into your work.
- A collection and/or research permit, depending on the space you want to work in.
- Financial resources to support staff time to develop and implement the program, to purchase supplies, and to pay for student transportation (if necessary).

Crediting This Guide

If you use the program model shared in this guide to develop your own community science education program, we'd love to hear about it! Please reach out to us at ***info@crystalcove.org*** and let us know.

Please make sure to include the following text on any promotional materials about your new program, such as a website or teacher guide:

This program is based on an educational program model developed by Crystal Cove Conservancy, which was made possible through a 2020 grant from the Ocean Protection Council and Coastal Quest's MPA Outreach & Education Small Grants program. To learn more, please visit https://crystalcove.org/mpa-model/.

What to Expect Next

As you move through the rest of this guide, we'll walk you through the process that we use to develop our own community science education programs.

1. Conducting a needs assessment
2. Developing partnerships
3. Creating a project plan with goals, a timeline, and a budget
4. Setting up a research project
5. Planning the educational program

Once you're ready to start developing the educational program, you'll need to make the following decisions:

- Choosing an audience
- Adapting your research question for your audience
- Making logistical decisions about where, when, and how you'll deliver your program.
- Developing learning outcomes and assessments.
- Setting up a unit guide.
- Setting up a lesson guide for each of the six sessions:
    - Session 1: Asking Questions
    - Session 2: Developing a Model
    - Session 3: Background Research
    - Session 4: Collecting Data
    - Session 5: Analyzing Data
    - Session 6: Sharing Your Findings

As you move through the rest of the guide, feel free to take it at your own pace. Good luck on your journey to creating your own community science education program!

Resources

The following resources provide more information about community science. You can also learn more about each resource in the Annotated Bibliography appendix at the end of this guide.

- ***Learning Through Citizen Science: Enhancing Opportunities by Design***
- ***Developing a Citizen Science Program: A Synthesis of Citizen Science Frameworks***
- ***Forest Service Citizen Science Planning Guide***
- ***Federal Crowdsourcing and Citizen Science Toolkit***

Reflect

- What is Crystal Cove Conservancy's model for community science education programs?
- Does our approach to learning reflect your organization's values? Does it seem like it would work for you?
- What will you need to do next to design your own community science education program?

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Needs Assessment

Steps to Designing a Community Science Program

Before you start planning a new community science program, it's important to learn about the needs of your community!

A needs assessment can help you identify the needs and gaps related to a project. Conducting a needs assessment will allow you to determine any needs within your organization. It can also help you build an understanding of the needs of your partners, audience, and community members.

By conducting one you'll be better prepared to plan an MPA-related community science educational program that meets the needs of your organization and community.

What You Will Do

As you read through this guide, you'll learn more about how we plan a needs assessment. You'll brainstorm potential stakeholders or other partners that you should talk to before beginning to plan your project, both within and outside of your organization. You'll also find resources on how to plan interview or survey questions.

By the end, you'll be ready to plan your own needs assessment!

By the end of this guide, you will be able to...

- Describe how a needs assessment can help you plan a community science research project and educational program.
- Identify the stakeholders that you might reach out to and begin planning your needs assessment.

Types of Needs Assessments

Needs assessments can be formal or more informal. Either type can help you get a sense of the observed and expressed needs of your organization, community, and stakeholders.

A ***formal needs assessment*** typically involves following an in-depth process to plan and collect data from a large number of stakeholders. If you plan to apply for funding that requires specific documentation related to the audience's needs, you may need to conduct a formal needs assessment.

During an ***informal needs assessment***, you might use surveys or interviews to gather data from your stakeholders, but they might not be as extensive or involve as many participants as a formal needs assessment. Even if you don't have a lot of time or resources to conduct an extensive needs assessment, an informal needs assessment can still be helpful and inform your decisions.

This guide will give you the tools to plan an informal needs assessment. If you feel that a more formalized needs assessment is necessary for your program, ***Designing Education Projects: A Comprehensive Approach to Needs Assessment, Project Planning and Implementation, and Evaluation*** by the National Oceanic and Atmospheric Administration is a helpful manual for completing one.

Deciding Who to Talk To

When conducting a needs assessment, you will want to talk with all of the stakeholders who will be involved in the project and those who may have an interest in the project even if they are not directly involved in it. These stakeholders will come from within your organization, your partner organizations, your audience's organizations, and community members who have an interest in your MPA and your project.

Take some time to consider stakeholders from each of these categories and the kind of information you want to get from them to ensure that your project will meet their needs. Some guidance for each type of stakeholder is provided below to get you started thinking about how to engage with them.

Your Organization

While you may feel confident about the needs of your department and organization, it can be helpful to take some time to examine the assumptions you are making about your needs and check in with colleagues to see if new needs have arisen that can be addressed with the MPA project.

Within your organization, you may want to talk to your executive director/president to find out more about their vision for a program. You may also want to talk to the education team, the conservation team, or people already working with school groups or the public, such as educators or volunteers.

Not all of the following questions will apply to all internal stakeholders, but some questions that you might think about asking within your organization include:

- Why do we want to develop a community science education program?
- Do we already run education programs? If so, what are the content areas where we have gaps?
- Are there past and current partners that we would like to work with again that would be a good fit for this initiative?
- Are there new organizations that we would like to start to collaborate with that would be a good fit for this initiative?
- What is the budget for the initiative?
- Do we need to seek funding or a grant for this project or do we already have funding to support this work?
- Are there other departments that I should consult to see if there are conflicts or synergies related to this initiative?
- Are there community members that we should invite into the conversation who haven't been able to share their perspective with us in the past?

Partners

Your partners are a key component to the success of your project, and a good relationship with partners will allow you to have more of an impact than you would have working on your own. Partners may include land managers, Tribal groups, scientists at universities, scientists at private consulting firms, and companies that own boats.

In a strong and healthy partnership, all members benefit and feel that they are making a valuable contribution to the overall project. It takes time to create the trust that is necessary to build a strong relationship, and it is important to start that relationship with learning more about the needs of each partner. By taking the time to ask questions and not make assumptions about their needs, you are demonstrating that you genuinely care about their interests and are committed to working together to make the partnership beneficial for everyone.

When considering the needs of partners, make sure to consider the different perspectives of the people involved. For example, if you're planning on running a program on board a fishing vessel, the owner of the boat company may have different needs than the captain and crew who operate the vessel during your programs. It's important to find out everyone's needs so that each person feels involved and appreciated for what they bring to the partnership.

Some questions to ask your potential partners:

- Why does this project interest you?
- What are your priorities for the project?
- How will you use the data that is collected?
- How involved do you want to be in the project?
- What is your preferred method of communication?
- How often do you want to communicate?
- Are there conflicts that you see arising from this project?
- Are there synergies that you see arising from this project?
- Are there other members of your organization who we should talk with to learn more about their needs?

Districts, Schools, & Teachers

Oftentimes, when we start to design a community science program like the MPA Exploration, we begin by meeting with district leaders, such as the district's STEM Coordinator or Teacher-on-Special-Assignment who specializes in STEM learning. These district leaders can give us an idea of district priorities and may be able to help us identify teachers or schools that would be good to work with. Other times, we'll host a small focus group of teachers to gain an understanding of their needs and how we can support them.

Some questions to ask a district or educational leader who manages multiple grade levels:

- Why does this project interest you?
- What are your priorities for the project?
- How will you use the data that is collected?
- How involved do you want to be in the project?
- What is your preferred method of communication?
- How often do you want to communicate?
- Are there conflicts that you see arising from this project?
- Are there synergies that you see arising from this project?
- Are there other members of your organization who we should talk with to learn more about their needs?

Some questions to ask a teacher:

- What grade or class do you teach?
- Which science content areas do you address in your class?
- How much time do you dedicate to science each week? How long does a typical science class or science lesson last?
- Is there a certain time of year when you teach a unit that would align with an MPA program?
- Do you have any challenges with incorporating technology into your classroom?
- What would make you excited to take part in an MPA community science program?
- Are there any science or math standards that you would want an MPA program to address? Is there anything else that you would want students to get out of the program?
- What do you think your students already know about MPAs or the ocean? How often do they visit the beach or engage in ocean-related activities?
- When going on field trips, what are the logistical restrictions that you face?

Community

Your community members are also stakeholders in your initiative. A needs assessment gives you the opportunity to ask them about their needs and their desire and capacity to engage in the initiative.

Community members who may want to be informed about or involved with your initiative include people who live near the MPA, Tribal Nations or other Indigenous-led groups who have a connection to the MPA, local environmental groups, and other organizations that conduct research in MPAs just to name a few. You may also want to reach out to members of your county's ***MPA Collaborative*** to see if you can share your project at one of their quarterly meetings.

It takes time to develop a relationship with community members so that they will trust your organization enough to contribute to an initiative. If you are going to a community or a group within a community that you haven't previously worked with, anticipate that it will take time to develop that relationship and that you will need to demonstrate your commitment to including them in the initiative so that all parties benefit. If possible, work with a person or organization that already has ties to a community to make it easier to earn trust and start to build a relationship.

When you get ready to conduct an informal needs assessment with community members, be prepared to share a short description of your organization, your community science project, and the educational program that you're looking to create. After introducing yourself and your project, it's helpful to have a list of questions prepared so that you can collect information from the community members.

Some questions to ask community members:

- Why does this project interest you?
- What are your needs?
- Are there conflicts that you see arising from this project?
- Are there synergies that you see arising from this project?
- Are there any possibilities for collaboration?
- To what extent would you like to be involved in this project? Would you like to be informed about progress? Or, would you like to play an active role in the project?
- Are there other community members or groups that we should contact?

Resources

- ***Designing Education Projects: A Comprehensive Approach to Needs Assessment, Project Planning and Implementation, and Evaluation*** by the National Oceanic and Atmospheric Administration (NOAA) is a helpful manual for completing a formal needs assessment.

- NOAA's online ***Needs Assessment Guide*** provides step-by-step guidance for how to conduct a needs assessment for people who already have some familiarity with the process.

Reflect

- What is a needs assessment? How will conducting one help you plan your program?
- Who might you talk to internally within your organization? What questions will you ask them?
- What external stakeholders will you talk to? What questions will you ask them?
- If you want to conduct a formal needs assessment, where can you find resources to help you plan it?

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How to Set Up Partnerships

Steps to Designing a Community Science Program

Strong and lasting partnerships can help sustain your community science program.

We've found that partnerships are essential in engaging students in real research within a Marine Protected Area. Partners can help provide expertise or resources that your organization may not have. But it's also important to have processes and structures in place to ensure that you understand your partners' motivations and needs so that you can work together effectively!

As you begin to explore different kinds of partnerships, you'll identify what help you might need to make your project a success!

What You Will Do

As you read through this guide, you will learn about the different types of partners involved in setting up a community science education program in an MPA. You'll also learn different tips for setting up, formalizing, and sustaining partnerships with each type of organization.

By the end, you'll be ready to start finding and establishing partners!

By the end of this guide, you will be able to...

- Describe the different types of partnerships involved in setting up an MPA community science program.
- Reflect on strategies to create, formalize, and sustain different partners.

Thinking About Partnerships

One major goal of MPA community science programs is to involve students in real research within an MPA. Most organizations do not have all the expertise to accomplish this on their own, which makes partnerships necessary. During your needs assessment, you may have identified some holes related to expertise or resources that you'll need to fill. You may have even identified some possible partners who are interested in getting involved in your project.

As you're starting to think about possible partners, you'll find the different types of partners that we've included in our MPA Exploration program below:

Session	*Overview*	*Examples*
Resource Managers	Can share their big-picture questions involving the MPA, as well as what student-collected data might be useful for them. Likely will also be involved in the process of getting a research permit.	Department of Fish & Wildlife; California State Parks; other land management agencies
Researchers	Can help develop real research questions and/or advise in the development of data collections protocols for students.	University researchers, graduate students, & other scientists
Educators	Can provide or help recruit students for your program. Some teachers can also be very helpful in creating or giving feedback on lesson plans.	Schools, after-school groups, etc.
Tribal Groups	Can inform you of the best way to incorporate their ideas and perspectives into your work.	Tribal Nations, other Indigenous-led nonprofits
For-profit Groups	Can provide resources your organization might not have, like access to a boat with scientific equipment.	Fishing companies, environmental consulting companies

Partnering with Resource Managers

Partnering with resource managers ensures that the data that you're collecting is useful and impactful. Resource managers can advise on what students could do that could inform their management decisions. Resource managers can also help with getting research permits and permission to conduct research within the area they manage (although you should always check for other legally required permits too).

In our MPA Exploration program, we partner with Crystal Cove State Park's environmental scientist, who has helped us to refine the questions that students are answering. Although we met more frequently at the beginning, we still make sure to communicate with the environmental scientist several times during our program season. In addition to our Department of Fish and Wildlife collecting permit, we also renew our State Park research permit every year to make sure we are permitted to conduct scientific research within the underwater park. At the end of the permit period, we write up a summary of our data and share it back with the environmental scientist.

As you begin building partnerships with resource managers, you may want to consider the following tips:

- Different MPAs may have multiple land management agencies managing different parts of the Marine Protected Area. It is important to check who is managing your local area, and make sure you're aware of any required permits, even if you chose to work with one specific agency more closely.
- Many state government agencies cannot accept stipends or outside pay, so resource managers will need to find time within their workday to collaborate with you. This can create challenges since many resource managers usually have lots of responsibilities with a very small staff. Be patient and understanding about their limited time, and make sure to ask them about the best way to communicate with them.
- Resource managers may have concerns about how student access and data collection could impact sensitive sites. Make sure you are sensitive to their concerns and work with them to find ways to get students involved in research that will not be harmful to the marine ecosystem.
- Since raw data can be time consuming for resource managers to process, plan to analyze and summarize your data before sharing it with them. Making sure to share your results can help create a long-lasting and mutually beneficial relationship.

Partnering with Researchers

Partnering with researchers can help ensure that students are participating in real research. They can help develop research questions, establish student-friendly scientific protocols for data collection, and assist you with analyzing data. Many are very interested in outreach and want to help inspire the next generaton of scientists!

In the MPA Exploration, we partner with a few different types of researchers. Scientists from University of California, Irvine have worked with us to help set up our research questions and protocols. We have been included in their NSF grants as their outreach component to help continue our work with them. We also partner with the California Department of Health, who provide us with nets to collect phytoplankton during our trips. We then mail them a phytoplankton sample so they can use it to monitor for toxic phytoplankton.

As you start thinking about how to partner with researchers, some tips that you may want to consider include:

- Like resource managers -- like all of us, really -- university researchers can get very busy with their own research projects and classes. Be respectful of their time, and be prepared to give them a clear idea of the expected time commitment.
- Graduate students within universities can be a great partner. If their thesis, or a portion of it, can be included within your MPA community science program, the graduate students may have more time to help with your organization's program. Many times, graduate students are willing to help on field trips and provide a real university connection to students.
- Try to connect with researchers who are already interested in public or school-based outreach. Although it will take longer to get established, you may also ask a potential research partner about writing your program into a research grant. Many research grants require a community outreach component. Student field trips can be a perfect way for a scientist to communicate their work to the public and can make their grant proposals more likely to be funded.

Partnering with Educators

Establishing a partnership with school districts, schools, or after-school programs can help your community science program in multiple ways. Teachers or other educators can provide great feedback on your program's curriculum, especially if you are providing pre- and post-trip in-class lessons. This can be mutually beneficial for your organization and the educators if you can provide scholarship funding for their class field trips in return.

We have about 60 teachers who participate in our MPA Science Exploration program. The vast majority of these teachers participate in an annual teacher training with us and receive scholarship funding to cover the costs of their buses, substitutes, and program fees in return. However, we have a much smaller core team of 3-4 teachers who help us pilot new curriculum and provide us with more regular help and feedback. We have found it very useful to have a close relationship with a few teachers who will let us try new things out and give us open and honest feedback. Providing stipends to teachers like this will help offset the time they spend working with you.

As you explore new partnerships with educators, you may want to think about the following:

- Partnering with districts and teachers can be challenging since they are always busy and usually over committed. There are a few different ways to get their attention. One position that can be very helpful in connecting you with teachers is the district's Science Specialist or Science Teacher on Special Assignment (TOSA). Science TOSAs help teachers integrate new science curriculum into their classrooms, so they are usually looking for new, innovative programs to get involved with. They can connect you to the best teachers who would be interested and committed to community science programs. Science curriculum coordinators can help in the same way as TOSAs.

- If you don't have any current connections to classroom teachers, it can be helpful to present your programs at district meetings. Science curriculum coordinators or TOSAs can help facilitate this. Their contact information can be found on most district websites.

- When contacting teachers, TOSAs, or curriculum coordinators, it is helpful to have an idea of the expected time commitment and include how your program aligns with ***Next Generation Science Standards*** (NGSS). You can learn more information on NGSS later in the guide in the ***Choosing an Audience*** section.

- As well as teachers, you might also consider partnering with other types of educators, such as after-school programs, summer programs, or scout groups.

Partnering with Tribal Groups

Historically, many Tribal Groups have been excluded from conversations around MPAs, and their voices are often not included in educational programs or tools developed for learners. Partnering with tribal groups can help uplift their voices and perspectives within their rightful and historical lands.

In the MPA Exploration program, we began partnering with members of our local tribes in 2020 through a local Indigenous-led non-profit, Sacred Places Institute for Indigenous People. With their help, we've been exploring new ways to include indigenous voices throughout the program so that students develop a respect for the Native Peoples whose lands and waters they are occupying.

As you start to explore partnerships with Tribal groups, considering the following tips:

- Tribal Governments are nations in their own right, and should be respected and treated as such. Internal conversations often take time, so be patient and respectful.
- It is especially important to be prepared to pay Tribal advisors for their work. Make sure to talk to them about what size stipend would be appropriate, and include it in your budget.
- Be aware that in California, some Tribal Nations are not federally recognized. Make sure that you are talking to all of the Tribal groups in an area whose historic lands and waters include the MPA.
- Establishing trusting relationships with Indigenous groups that have long been excluded and maligned takes time. Make sure to enter any discussions with the intent of forming a two-way partnership and make sure to listen for what Indigenous partners may want to get out of a collaboration.

The United States Department of Agriculture gives some advice and resources for partnering with Tribal Nations in their ***Forest Service Citizen Science Project Planning Guide*** on page 15. Be aware that this information is presented through the viewpoint of a U.S. governmental agency, and not by the Tribes themselves.

Partnering with For-profit Groups

For-profit companies may have access to resources that you do not, such as transportation and specialized scientific equipment. Some for-profit companies may be more interested in a typical customer relationship with you, especially if you are only looking to run a few programs each year. But others may be interested in developing a more in-depth relationship.

The MPA Exploration program originally developed out of our partnership with Newport Landing Sportfishing (NLS). NLS provides fishing vessels to bring students on the water in the Crystal Cove State Marine Conservation Area. Both organizations see this as a win-win relationship: we are able to bring them business during the times of year when they are most slow (weekdays during the school year). In return, they donate a portion of their proceeds to support our work.

Not every community science program may need a for-profit partner, but if you're considering one, read over the following tips:

- Make sure that any relationship is mutually beneficial to both organizations. Sit down with the for-profit company and find out what they want to get out of a potential partnership. It is often worth considering formalizing the agreement through a memorandum of agreement or contract (more on that below).
- Nonprofits and fishing communities have different cultures and goals, so clear and open communication has been key to keeping a strong partnership. When issues have arisen, we set up meetings with an open discussion between the owners, education staff, and the fishing crew to get them resolved.
- We've found that it is also very important to establish respect between our two companies. As educators, we are stepping onto a boat that is not ours and we are not experts about. While on the boat, we have to be respectful of the captain and the crew. They are in charge of the vessel while we are in charge of the education component. We each respect the positions we hold.
- Understand that money is an important consideration for both for-profit companies and their employees! In our partnership with Newport Landing Sportfishing, we realized early on that the boat crew was getting frustrated because while they often received tips during fishing trips, they did not get tips during our education programs. They depended on these tips to make rent and survive! We addressed this by paying each crew member a stipend to make up for the lost tips.

Meeting with New Partners

As you begin meeting with potential new partners, you'll want to make sure you are utilizing time well. As a result it's extremely important to be prepared for the initial meeting.

Here are some questions to consider for the initial discussion:

- What are your goals for this partnership? What do you want to get out of it?
- If this partnership is a success in your eyes, what will it look like at the end of one year? After five years?
- What expectations do we have for each other?
- How will we communicate with each other? Who will be each organization's point of contact? How and when will we talk: by email, by phone, through regular meetings?
- Is there anything that I should know about the typical rhythm of your year?
- How do you want to be involved? Are there specific points in this project when we should check in with each other?

Formalizing Partnerships

Formalizing partnerships isn't always necessary, but can sometimes be very helpful, especially if money is involved. It is also a good way to make sure everyone's goals are laid out and clear. There are a few possible options to formalizing partnerships:

Summary of Shared Goals	An informal document that gives you and your partners a chance to think through what you all want to get out of the project. This can help to make everyone's motivations and needs explicit. Very informal; not legally binding.
Memorandum of Agreement	A document that explains an agreement between two parties, broadly outlining how you plan to cooperate and work together. It is often signed by both parties. It can be legally binding or just a formalized agreement that is not legally enforceable, depending on the language that you use.
Memorandum of Understanding	An often legally-binding document that lays out the ground rules for cooperation between two organizations. Common with government agencies. It likely includes specifics on how you plan to work together, including who will take on what responsibilities, who will own intellectual property, and what will be required of each party (including how money or other resources will be exchanged).
Contract	A legally-binding document between two parties that creates an obligation to do a particular action.

With our partners, we use a variety of different strategies to formalize our partnerships. Since Crystal Cove Conservancy is Crystal Cove State Park's cooperating association, we have a contract that outlines our obligation to the State Park, though it is not specific to the MPA Cruise program.

We created a Memorandum of Understanding with Newport Landing Sportfishing, which details agreed-upon outcomes for the project, how money moves between our organizations, and what will happen to the intellectual property we've created if the partnership ends. We generally update and sign the MOU every 2-3 years. You can view a template for a similar MOU online ***here***.

With UC Irvine (our main research partner) and our K-12 schools, we do not have a formal partnership agreement in place. Instead, we share mutual goals and have developed informal communication strategies with each other over time. Teachers choose to participate or not participate each year with no obligation to continue in the program.

Resources

- ***Forest Service Citizen Science Project Planning Guide*** by the United States Department of Agriculture provides information on successful partnerships.

Reflect

- What are the different types of partnerships to consider when setting up a community science program?
- What are some considerations to keep in mind as you start to work with each type of partner?
- What might you ask at an initial meeting with a new partner?
- What are the different options to formalize a partnership?

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Creating a Project Plan

Steps to Designing a Community Science Program

Planning for your community science project is a key component to its success.

There are a lot of tasks that need to be accomplished to plan, design, and implement a successful MPA community science educational program. It is worth the time and effort to create some planning documents to guide you along the way.

By taking time to reflect on your project goals and put together a timeline and budget, you'll get a sense of the resources and time that you'll need in order to successfully plan and run a program with students.

What You Will Do

As you read through this guide, you will reflect on the goals and objectives you have for your research project and educational program. You will create a timeline to keep you and your team on track. You will also learn how to create a project budget to ensure that you have the necessary resources to implement your project.

By the end, you will have a plan that will allow you to feel confident about planning, developing, and implementing your project!

By the end of this guide, you will be able to...

- Describe the goals and objectives of your project.
- Create a project timeline and budget.

Set Goals and Objectives for Your Project

When you're starting to plan a new project or program, it's always helpful to take time to reflect on your goals and objectives. Goals are typically general ideas of what you want to accomplish, which may or may not be easy to measure. Outcomes are more specific and are often written so that they can be measured and assessed.

Your community science project may have multiple goals and objectives in terms of the scientific research project and the educational program. It is important to have a discussion about these goals and objectives within your organization and with your key stakeholders. That will help you come to a shared understanding about what you want to achieve and ensure that the goals and objectives of your organization are aligned to support the needs of all stakeholders.

As you think about goals and objectives, you might consider different categories.

Questions to consider as you're thinking about goals and objectives related to your scientific research project:

- What environmental issues do you and your stakeholders want to study in the MPA?
- What questions do community members or local resource managers have about the MPA? What types of recommendations might you want to make in response?
- What impact do you want to have by studying the environmental issue?
- If your work is a success, how might the MPA look different in five years? In fifty years?

Questions to consider for goals and objectives related to your educational program:

- What learning objectives do you and your stakeholders have for the program?
- What impact do you want to have on the students and teachers who participate in the program? What key messages do you want them to learn?
- How do you want students and teachers to engage with your stakeholders? What impact do you want them to have on their community?
- Is there a certain number of students and teachers that you want to include in the program? Do you want to grow the number of participants over the years?

Other questions to consider:

- What outputs do you want to create as a result of the program? This could include the number of lesson guides you'll publish, field trips, etc.
- What do you want to achieve related to partnerships? Are there specific new partnerships that you want to develop or establish?
- Is there anything else that you want your project to accomplish?

Once you've considered your goals and objectives, it's also worthwhile to think about how you might measure whether your final program is successful. If you'd like to conduct a full program evaluation to assess your success,

Reflect on Possible Partnerships

Once you've reflected on your goals and objectives, the next step is to consider how partners can help you achieve those goals and objectives.

The previous chapter includes specific tips on setting up partnerships, so at this stage, you might think about the partners that you considered while reading through Chapter 3 and how each partner could help you achieve the goals and objectives you have for your program. Ideally, you would have conversations with each partner to create shared goals and objectives so that the needs of each partner are met through the program. By reflecting on your goals and the partners you are considering, you may identify some holes and may decide to seek out some additional partners.

Questions you may want to ask partners to find out if your goals are aligned include some of the same questions you asked yourself when identifying your goals and objectives, including:

- What environmental issues do you want to study in the MPA?
- What impact do you want to have by studying the environmental issue?
- What learning objectives do you have for the program?
- What impact do you want to have on the students and teachers who participate in the program? What key messages do you want them to learn?
- What outputs do you want to create as a result of the program? This could include the number of lesson guides you'll publish, field trips, etc.
- What do you want to achieve through a partnership?
- Is there anything else that you want this project to accomplish?

Create a Project Budget

Next, you'll want to think about your project budget. Your budget should include expenses like staff time to support the development of the project, research permit fees, and stipends for partners, as well as direct expenses such as supplies, instructor wages, and transportation costs for students.

We tend to think about our program budgets in terms of phases: design, implementation, and evaluation. This lets us explain to both internal and external stakeholders about why we need certain funding -- especially for staff time.

Below, you'll find an example budget for Year 1 of a new MPA community science education program. If you'd like to see an example of a more traditional budget or other expenses that you might want to include, check out the Forest Service's ***Citizen Science Toolkit***.

Category	***Description***	***Example Amount***
Program Development	This includes conducting a needs assessment, developing a program plan, and developing curriculum. This will typically be *much* higher during Year 1, and will reduce significantly in future years.	
Staff Salary & Wages	This includes staff time to conduct a needs assessment, meet with partners, develop the program goals, write lesson plans, and test program elements. Depending on the complexity of the program and the number of staff involved, you'll likely want to budget 500-1000 hours per person during your first year.	$20,000
Benefits	We typically calculate this at 20%, but it may be different for your organization.	$4,000
Partner Stipends	If you have partners helping with the project, especially Tribal Groups, you may want to budget stipends to support their involvement.	$6,000
Total		***$30,000***

Category	Description	Example Amount
Participant Recruitment	This includes the costs of recruiting teachers to take part in your program.	
Staff Salary & Wages	We usually assume a staff member will spend 20-30 hours performing outreach to teachers.	$500
Benefits	We typically calculate this at 20%, but it may be different for your organization.	$100
Advertising Costs	This may not be necessary, but could include graphic design for a flyer, social media advertising, etc.	$200
Total		***$800***
Program Implementation	This category includes direct costs of running the program. Below, you'll find the estimate for one class's participation.	
Staff Salary & Wages	This may vary depending on how you design your program, how many people are required to teach it, and how long it will last. Our estimate here assumes three staff members working 20 hours each.	$1,200
Benefits	We typically calculate this at 20%, but it may be different for your organization.	$240
Supplies	This will be much higher in Year 1 than in later years and can vary a lot depending on your project. For our boat-based program, a full set of equipment (including six laptops, water sampling sets, underwater cameras, etc.) costs $12,000, but simpler research projects will require much less.	$2,500
Staff Transportation	This might include mileage for staff to get to the project site or parking fees once they arrive.	$60
Participant Transportation	We've found that bus costs can vary a lot depending on the bus company and the distance. Often, district buses are cheaper than outside companies. This can vary between $300 for close schools with district buses to $1,200 for very long trips of 2 hours or more that require charter buses.	$500
Substitute Teachers	This is often not necessary for lower elementary grades, but you may need to cover this cost for middle or high school classes.	$200
Total		***$4,700***

Category	Description	Example Amount
Program Evaluation	You may also want to include a program evaluation or assessment in your budget. This can vary a lot, especially if you involve an outside firm. Below, you'll find the estimates for an in-house assessment.	
Staff Salary & Wages	We usually assume a staff member will spend 20-30 hours performing outreach to teachers.	$600
Benefits	We typically calculate this at 20%, but it may be different for your organization.	$120
Total		***$800***
Other Costs to Consider		
Permitting Fees	A California Department of Fish and Wildlife permit costs $400, as of July 2021.	$400
Teacher Stipends	This is not always necessary, but you may consider paying a stipend to participating teachers to offset their extra time working with you.	$1,000
Teacher Workshop Costs	If you're working with multiple teachers, you may consider hosting an in-person training day. Expenses might include lunch, facility fees, consumable supplies, etc.	$250
Indirect Expenses	This includes the costs associated with running your organization that might not be directly associated with the project. It could include rent for your office, electricity, executive salaries, etc. We typically budget indirect costs at 20% of our total expenses, but it may vary at your organization.	$6874
Total		***$8,524***

Create a Project Timeline

Finally, it's also helpful to create a timeline for your project to ensure that you and your team think through all the steps, stay on track, and are ready to implement the program on time.

Depending on how complicated you want to get, you can set up your timeline in different ways. A simple timeline might just use a table with different columns to indicate activities or milestones, the person responsible, and the timeframe for completion. If you want to be more thorough, you can use a project management tool called a Gantt chart to create a more detailed timeline that shows how activities overlap. The Resources section below includes additional information about Gantt charts.

As you're thinking through your timeline, there are several major tasks that you may want to include. You can think about these in big blocks, or you may decide to break down each task into smaller steps to provide your team with the details of everything that needs to be done.

Below, you'll find some of those major tasks, along with an estimate of how long you might expect each phase to take.

Tasks	*Notes*	*Allocated Time*
Meet with Stakeholders	At the beginning of the project, you'll pull together major stakeholders.	1-2 days
Meet with Partners	Once you've identified key partners, you'll likely want to bring them together to discuss the project and then set a regular meeting cadence. Although meetings may be short, you'll want to think about how frequently to check in.	2-4 hours, meeting at set intervals throughout the project
Conduct Needs Assessment	Although this may only involve a few meetings, it can take varying amounts of time to complete depending on people's schedule.	2-4 weeks
Develop Project Plan	This can happen concurrently with the step above and may involve conversations with partners.	1 week
Develop Research Questions and Research Project	This will vary a lot depending on whether you start with an existing project or develop a new one from scratch. It may involve multiple meetings with partners.	2-4 weeks

Plan and Develop Curriculum Materials	This involves the development of all curriculum materials, including lesson guides, data collection protocols, data forms, and all supporting materials. This process can become very lengthy, depending on the number of staff involved, their expertise with curriculum design, and the percentage of time they have to devote to the project. We recommend devoting at least 2-3 months to curriculum development.	2-6 months
Plan Program Evaluation	The length of this may vary a lot depending on staff expertise and whether you're working with outside partners.	1 week or more
Purchase Equipment and Supplies	This often takes more time than you think! Make sure you allow enough time for all supplies to be ordered, delivered, and organized.	1 week
Hire Staff Members	If you need to hire new educational staff to implement the project, you will want to plan enough time to develop a job description, receive resumes, conduct interviews, select staff, and have them start. This can happen concurrently with other steps.	3 months
Recruit Teachers	Although this may not involve a lot of hours, this can be a slow process, especially because teachers can be slow to respond. We recommend planning at least 2-3 months for teacher recruitment.	2-3 months
Implement Program	This will vary in length depending on how your program is designed!	1 day to several weeks
Collect and Analyze Evaluation Data	We recommend leaving a month at the end of the program implementation phase to give yourself time to analyze any evaluation data!	2-4 weeks

Resources

- ***Forest Service Citizen Science Project Planning Guide***
    - ***Citizen Science Toolkit*** includes a comprehensive project template
- ***The Ultimate Guide to Gantt Charts***

Reflect

- What are the goals and objectives of your scientific research project and the educational program? Are they aligned with each other? Do your partners have similar goals and objectives?
- How will the project team be keeping track of our progress on planning and implementation? Do you want to use any specialized software to help you manage the project?
- Does your budget show that you have enough resources to successfully implement the project? Is it necessary to look for additional funding?

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How to Set Up Research Projects

Steps to Designing a Community Science Program

During a community science project, students can help to collect data on a Marine Protected Area!

The research or monitoring project at the heart of your community science educational program can help build understanding about how the ecosystem in the MPA is changing over time. You might invite students to participate in a research project that you're already running, join an existing project that was designed by another organization, or create a new monitoring project from scratch.

In this chapter, we'll share suggestions for possible MPA-related projects that you might join, ways to adapt an existing project for students, and resources on how to design and set up a new community science research project. Then, later in the guide, we'll describe the process to design an educational program around your selected research project!

What You Will Do

As you read through this guide, you will consider your options for setting up your research project. You'll think through whether you want to join an existing project, adapt your current project, or start one from scratch. You will also find links to other sections of this guide that provide more information and to free online resources that can guide you through the process of setting up your research project.

By the end, you'll be ready to set up your own research project!

By the end of this guide, you will be able to...

- Describe different options for setting up a research project, including joining an existing project or setting up your own.
- Describe how you can modify a research project to include students.

Deciding on Your Approach to the Research Project

The goal of every community science educational program is to position students so that they are able to contribute data to a real research project. Ideally, this project will help to inform local natural resource managers and help scientists gain a new understanding about how ecological mechanisms work.

Although you can set up a new research project from scratch, doing so involves a lot of specialized expertise and will likely require that you partner directly with a scientist. Alternatively, you could adapt an existing research project that your organization is already involved in or join a statewide research project run by another organization.

As you think about the best approach for your organization, reflect on the following questions:

- Do we already have a research project that we want to adapt to include students?
- Do we want to participate in an already established research project and contribute data from our location?
- What question is that project answering? What are our data needs?
- Does the research project align with our educational program goals?
- Does the research project align the needs of our partners and audience?
- Do we want to start from scratch and design a new research project? If so, what experience do we have with designing a research project? Is there a scientist or other partner who might be able to use our data?

Existing Community Science Projects

One of the easiest ways to get started is to join an existing research project and build your community science education program around that!

If you would like to contribute data to an existing research project, below are some suggestions. Note that you'll still need to design an educational program around the data collection project that you choose -- these will simply give you a place to share your data.

Crystal Cove Conservancy's MPA Cruise

Crystal Cove Conservancy's MPA Science Cruise gives junior high and high school students the opportunity to visit the Crystal Cove State Marine Conservation Area on a boat to monitor changes to the water chemistry and the plankton and fish populations. If you're interested in designing a similar boat-based program, we'd love to share our protocols with you and have you contribute data from another MPA.

California Academy of Sciences' Snapshot Cal Coast

For two weeks every year, Snapshot Cal Coast asks people to visit their local MPA or coastal area to use a free app called iNaturalist to share photos of as many species as possible. This builds an annual snapshot of biodiversity along the California coast. The data collected through iNaturalist is valuable to scientists at local, regional, and state levels.

Each year, the Cal Academy shares a few targeted research questions, which usually involve tracking invasive species along California's coast. But you can also create your own research question focused on local concerns.

Volunteers in this program do not need to attend a formal training session or attend a formal program. They just need to visit the coast during the designated time frame and use the iNaturalist platform to share the observations that they make at their local MPA.

MPA Watch

MPA Watch is a community science program where volunteers collect scientific data on how people use coastal and marine resources. Volunteers are trained to collect data on the activities of people when they visit an MPA, such as surfing, kayaking, fishing, boating, running, etc. This information is useful in managing MPAs and supports the efforts of the California Department of Fish and Wildlife.

Organizations throughout the state train volunteers to collect data at the MPAs in their region. To learn more about how to be trained for your local MPA, contact the ***program representative*** from your area.

LiMPETS

LiMPETS (Long-term Monitoring Program and Experimental Training for Students) is a citizen science program that monitors the coastal ecosystems of California and helps youth develop a scientific understanding of the ocean. LiMPETS monitors the marine life in rocky intertidal and sandy beach ecosystems and provides long-term data to inform marine resource management and the scientific community. The sandy beach monitoring program is designed for 6th graders through college students. The rocky intertidal monitoring program is designed for 9th graders through college students.

Schools and environmental education organizations pay a small fee to participate in the program. Leaders and students are trained by LiMPETS coordinators and receive support to help them adhere to the LiMPETS protocols and standards. To learn more about how to get involved, visit ***this page*** on the LiMPETS website.

Setting Up a Monitoring Project

If you want to start a new monitoring project from scratch, it will take time to think through all of the components. You will need to consider the environmental issues that are of interest to you at your local MPA and how they could be used to create a research question and project. The process of deciding on the issue and focus of your research project will require you to talk with resource managers, community members, scientists, and other stakeholders. Working together with stakeholders will allow your project to be more impactful and will give students an opportunity to truly contribute to important scientific research.

You'll want to connect with the resource managers for your MPA early on in the process to talk with them about regulations, the types of research questions and data that are of interest to them, and the data collection protocol that they would recommend. They may also have specific requirements for what you can and cannot do.

If you are partnering with a scientist from a university or from the local resource manager's office, you will need to talk with them about data quality and management to ensure that the data collected by students is usable and managed properly. They can help you think through the steps to creating and implementing training sessions and data collection protocols to ensure that the data quality will be sufficient for their use. They can also help you think about your options for data analysis.

You will also need to connect with teachers and/or school district administrators to ensure that you will be able to engage with students who will be able to collect data for your project in a way that also meets the needs of the students, teachers, and district. This will take time, so make sure to approach teachers and administrators early on in the process so they can be involved in the planning and be ready to have students participate in your project at the same time as when you are ready to launch your project.

The following resources can help you think through the steps to setting up your research project.

- ***Federal Crowdsourcing and Citizen Science Toolkit***
- ***Forest Service Citizen Science Project Planning Guide***
    - ***Citizen Science Toolkit*** includes a comprehensive project plan template
- ***Planning Your Community-based Citizen Science Monitoring Project for Dam Removal and Watershed Restoration*** - The Center for Community and Citizen Science at UC Davis wrote this guide. While it is focused on Dam Removal and Watershed Restoration, it has information that would be helpful for setting up a research project in an MPA.
- If you need a digital home to host your community science project, consider using ***FieldScope***. FieldScope provides tools to help you manage your data, graph and map your data, manage your project, and manage groups that are working within your project.

Data Quality

Data quality is crucial to a successful monitoring project. Whenever you talk to researchers about getting K-12 students or other young learners involved in community science projects, their first concern is often about the quality of student-collected data.

We believe strongly that if we want students to meaningfully contribute to community science monitoring, we have to design first for data quality. If student data can't be trusted, it undermines the idea that they're taking part in real scientific research. This means that if you have to decide between these trade-offs, we strongly recommend prioritizing data quality first.

Talk with the researcher involved in your community science project, and ask them to help you come up with a plan to validate data quality. See the section below and Session 4: Collecting Data for more information on how to ensure that student data is of high quality and usable by scientists.

The ***Project Plan Template*** available from the US Forest Service is an excellent resource for making a plan for ensuring data quality and data management. The template provides definitions and examples for some key components of data quality, including precision, bias, representativeness, comparability, completeness, and sensitivity. The template format makes it easy to create a plan to ensure the quality of your data.

Getting Permits and Permission

In order to conduct a monitoring project within a Marine Protected Area, you may need to apply for a scientific collecting permit from the California Department of Fish and Wildlife (CDFW). Details about the regulations, application process, and reporting requirements are available on their ***website***. The permitting process can be tricky to navigate. If you have questions along the way, reach out and email ***SCPermits@wildlife.ca.gov*** with questions; they are very helpful and willing to assist.

As of July 2021, the California Department of Fish and Wildlife is not allowing any projects that utilize a manipulative experimental design to take place in an MPA. If you have questions about this, we highly recommend contacting CDFW.

If the MPA you are working in is also managed by another land management agency (e.g., California State Parks), you should contact the agency to find out what permission requirements they have for conducting monitoring and educational programs at their site. State Parks requires permits for scientific research that occurs within their boundaries, and other resource managers will likely have their own requirements as well.

Designing a Research Project so Students can Contribute

As you start thinking about how to adapt or structure your research project to involve students, there are strategies that you can use to help students successfully participate in a community science project while still ensuring scientific rigor. We'll go into these details later in the ***Adapting Your Research Question*** section of this guide.

As a summary, some of things you'll want to think about include:

- ***Adapting your research question:*** It will be easier for students to contribute to your research project if you create a scaffolded version of your research question so that the data analysis strategies are friendly for students.
- ***Considering your audience's capabilities:*** Some decisions will be influenced by the age of your students and the developmental capabilities of their age. For example, you should consider the age of your students when you select the project's location, equipment, monitoring protocols, and data analysis approach.
- ***Providing an opportunity for students to practice with equipment:*** In order for students to use equipment correctly to collect accurate data, they need to have an opportunity to practice using the equipment before collecting data that will be included in the dataset. This training session could take place in advance in the classroom, virtually, or on the day of data collection.
- ***Designing student-friendly instructions:*** The instructions for data collection should be created with students in mind so they can easily complete each step correctly. Strategies for this are described later in this guide.
- ***Designing a student-friendly data sheet:*** The design of the data sheet students use has a big impact on whether students can record the most accurate data on a consistent basis. Strategies that can be used to create effective data sheets are described later in this guide.
- ***Planning for student-friendly data analysis:*** Students can analyze data even at young ages, but you need to make sure you select an approach to data analysis that is aligned with the capabilities of the students' age.
- ***Ensuring data quality:*** Accurate data is crucial to the success of a community science project. Strategies you can use to ensure that students collect reliable data that scientists can trust are described later in this guide.

Legal Questions

During the course of planning or implementing your project, you may find that you have questions about laws and policies related to engaging in the work. Examples include questions related to automatic trail cameras, the use of drones, and The Children's Online Privacy Protection Act if you plan to have students under 13 use a digital app to collect data.

The Emmett Law & Policy Clinic from Harvard Law School has arranged for their students to answer questions that are submitted through an online form. You can view answers to previously submitted questions and submit your own at the ***Citizen Science Association's website***.

Resources

The resources below provide more detailed guidance on how to set up your research project. There are short descriptions for some of these resources in the ***Annotated Bibliography*** appendix at the end of this guide.

Online Planning Guides (listed alphabetically)

- ***Federal Crowdsourcing and Citizen Science Toolkit***
- ***Forest Service Citizen Science Project Planning Guide***
  - ***Citizen Science Toolkit*** includes a comprehensive project plan template
- ***Planning Your Community-based Citizen Science Monitoring Project for Dam Removal and Watershed Restoration*** - The Center for Community and Citizen Science at UC Davis wrote this guide. While it is focused on dam removal and watershed restoration, it has information that would be helpful for setting up a research project in an MPA

Books (listed alphabetically)

- ***Citizen Science for Coastal Marine Conservation*** - Book that includes several chapters that could be helpful, including Engaging Youth and Schools in Coastal Citizen Science: Balancing Both Education and Science Goals
- ***Handbook of Citizen Science in Ecology and Conservation*** - Book that includes 10 chapters on planning and implementing citizen science projects
- ***The Science of Citizen Science*** - Open access book that includes chapters that may be helpful for practitioners.

Reflect

- Do you have a research project in mind that you can adapt to include students? Or can you join an already existing project? Or will you need to start a research project from scratch?
- Who will you need to talk with to get the required permission and permits for your project?
- What concerns do you have about data quality? What can you do to ensure that the students will be able to collect data that will be usable by the scientists who are part of your project?
- What strategies will you use to ensure that students will be able to successfully contribute to the project?

Steps to Designing a Community Science Program

Helping students learn requires intentional planning.

With proper framing, community science projects can be designed to support science learning by immersing participants directly in the practices of science. But designing effective educational programs takes time and intention in order to ensure participants learn what is intended.

In order to ensure that an educational program is effective, you'll need to understand and incorporate best practices in education such as backwards design, scaffolding, integration of the Learning Cycle model, and strategies to support diverse learners. This will prepare you to apply these strategies later on as you begin designing your own MPA community science education program.

What You Will Do

In this guide, we'll revisit our model for developing an MPA community science education program. You'll also be introduced to several of the educational strategies that we use when designing educational experiences for learners from different backgrounds.

When you're done, you'll be ready to move on and start planning your own MPA community science education program!

By the end of this guide, you will be able to...

- Describe our model for community science education.
- Consider some of the different strategies we use to engage learners of different backgrounds.
- Describe the steps that you'll take to design your own community science educational program.

Our Model for Community Science Education Programs

When we begin designing a new community science education program, we use six different sessions that make up the student experience. This learning sequence is intended to mirror how professional scientists work, guiding students through the process of asking questions, designing a model, refining that model, collecting data, analyzing their data, and sharing their findings.

Session	Overview
1 Asking Questions	Students explore the local MPA, generate questions about its ecosystem, and reflect on how they might help protect it. They are also introduced to the community science research project that they'll take part in.
2 Building a Model	Students work in research teams to develop a model of the ecosystem.
3 Background Research	After identifying any questions about their model, students take part in background investigations to learn more.
4 Collecting Data	Research teams visit the MPA to collect data for their research project.
5 Analyzing Data	Research teams create visualizations to look for patterns in their data, and then use those visualizations as evidence to support a claim about their research question.
6 Sharing Our Findings	Research teams design a presentation to share their findings with community members or other stakeholders.

This model aligns with state learning goals for students of all ages, as detailed in the Next Generation Science Standards. (More on those in a bit.) It also follows best practices in science education by giving students a chance to make sense of real-world phenomena while working with messy real-world data.

A lot about our program model is intended to be flexible. In our programs, some of these sessions take place in the field, where students have a chance to visit the Crystal Cove SMCA and ask questions, make observations, and collect data. Others take place at students' schools, where teachers walk participants through designing a model or analyzing data. We've also found it easy to adapt the model for different age groups of learners. Depending on the time that schools have available, some of the six sessions may also be broken down into multiple class meetings.

Strategies to Support Learning

As educators, there are specific strategies that we use when we're designing programs in order to support learners and ensure that they're learning what we want them to.

As you read through the rest of this guide, we'll walk you through our design process, which integrates several educational best practices. These best practices include:

- Backwards design
- Intentional scaffolding and other supports for learners
- Integration of the Learning Cycle into our lesson design
- Specific strategies to support diverse learners from marginalized backgrounds

Backwards Design

When we begin designing a new program, we use a process commonly used by educators called Backwards Design. During this process, we start by developing learning goals and assessments first, and then plan the activities from there. This allows us to determine what we want students to know and then ensure that the activities we choose match those learning goals.

As you begin thinking about your own community science education program, we encourage you to follow the same process: plan your learning outcomes and assessments first, and then design each activity based on those goals. As you go through this guide, we'll provide you with specific suggestions for learning goals and assessments that you might use for the unit as a whole and for each individual session.

Scaffolding

One key aspect of a sociocultural approach to learning is that individuals need support from more experienced people to help them accomplish tasks or learn new skills and information. This support, called scaffolding in education parlance, allows a learner to achieve something that they would not be able to achieve if they were working on their own.

Scaffolds for a science project can come in different forms, including student notebooks with guiding questions, breaking up a complex process into smaller steps, providing videos that demonstrate how to use equipment or analyze data, and providing prompts for group discussions. The ***Tools for Ambitious Science Teaching website*** provides ideas for effective scaffolds that support students in their scientific writing and scientific discussions with peers.

As you go through this guide, we'll provide you with some specific scaffolds that you can use to support learners in the process.

Learning Cycle

The learning cycle is an instructional sequence used commonly in science education that guides learners through a scientific investigation. It moves away from lecture-based lessons by putting inquiry and student-driven investigation at the heart of each lesson. In science education, the learning cycle can take different forms. One common form is the BSCS 5E Instructional Model, which was developed in 1987 and remains extremely popular with science educators today.

For our program model, we use an adapted form of the learning cycle that breaks each lesson down into four sections. These sections align with the five elements of the BSCS 5E Instructional Model (although we use slightly different names):

- **Launch (or Engage):** At the start of every session, students are introduced to the day's driving question and share their initial ideas about the topic.
- **Explore:** Next, students take part in short investigations related to the module's driving question. These investigations are designed to be flexible, and can take place in the field or during scheduled class time at school.
- **Share (or Explain & Expand):** Students come back together to share their observations and discuss their ideas with their peers. These discussions may take place in student research teams or as a whole class. We have found it helpful to include slides with suggested science discussion norms, sentence starters, and suggested questions to get teachers started, which they can adapt for their class.
- **Reflect (or Evaluate):** At the end of each session, students respond to questions and reflect on what they've learned so far in their field notebook.

As you begin developing your own lesson plans for each of the six sessions, you'll have a chance to see this learning cycle in action.

Designing for Diverse Learners

Crystal Cove Conservancy holds diversity and inclusion as one of our highest tenets. Our commitment to diversity and inclusion is grounded in our aim to address the historical exclusion of Black, Indigenous, & People of Color from public lands, protected waters and the environmental cause itself. Because these communities have had limited access to natural spaces, they continue to be excluded and underrepresented in the science initiatives which aim to protect such lands and waters.

As a result, we intentionally partner with schools in disadvantaged communities to deliver our community science education programs. We recognize and appreciate that our learners come from diverse communities and have a wide range of previous experiences and knowledge that they contribute to the shared experiences during an MPA program.

There are a variety of strategies that can be used in the design of sessions to intentionally support the needs of students so that every student has the opportunity to successfully participate in the program. Below are some examples of strategies that we have found to be effective with our students. In each session guide, you can select appropriate strategies from this list or use others that you have found to be effective and make the most sense for your learners and your program.

Strategy	*Explanation of How it Supports Diverse Learners*
Providing a common experience	All students come to a program with different past experiences. Having a shared experience supports diverse science learners because it ensures that everyone has an experience in common that they can discuss and build on throughout the program. During our program model, we'll include specific suggestions for ways to build in these common experiences. Similarly, it is important to include time in a program to acknowledge different past experiences, and to give students time to share their own knowledge and relate it to the current experience.
Science notebooks	Science notebooks give students a place to record their observations and ideas, sketch models, record data, and reflect on how their thinking is changing over time. By giving them a place to process their thoughts on their own before sharing them with peers or a teacher, students can feel more confident about sharing their ideas with others. Throughout this guide, we'll provide tips and suggestions for integrating science notebooks (which we call field notebooks) into student learning experiences.
Supporting science discussions	Participating in science discussions can be challenging for students if they haven't had much experience with it, so establishing norms for discussions, giving sentence starters, and being generous with the amount of time designated for discussion can support all students and help them make positive contributions to a discussion. We'll share some tips and suggestions for engaging students in science conversations throughout this guide.
Breaking things up so students can do them at their own pace	When a task is complex and there are a lot of steps involved in order to complete the task, it is helpful to break the overall task into separate steps so that students can accomplish them at their own pace. This also makes the task less overwhelming for students who have less experience. In addition, we've found it's helpful to include video or screencasts that demonstrate complicated tasks. Using videos allows students to watch it at their own pace and pause and re-watch it if necessary until they are comfortable with it.
Student-driven choice	Giving students a choice for how to complete a task or which topic they want to explore allows them to have some control over a situation and allows them to tailor the lesson to something that is meaningful to them personally. This can increase motivation and make them more comfortable with the lesson.

What to Expect Next

As you move through the rest of this guide, we'll walk you through the process that we use to develop our own community science education programs.

- Choosing an audience
- Adapting your research question for your audience
- Making logistical decisions about where, when, and how you'll deliver your program.
- Developing learning outcomes and assessments.
- Setting up a unit guide.
- Setting up a lesson guide for each of the six sessions:
    - Session 1: Asking Questions
    - Session 2: Developing a Model
    - Session 3: Background Research
    - Session 4: Collecting Data
    - Session 5: Analyzing Data
    - Session 6: Sharing Your Findings

As you move through the rest of the guide, feel free to take it at your own pace. Good luck on your journey to creating your own community science education program!

Resources

- ***Information about BSCS 5E Instructional Model***
- ***Explanation of the 5E Instructional Model***
- ***Qualities of a Good Anchor Phenomenon for a Coherent Sequence of Science Lessons***
- ***Scaffolding Tools for Scientific Writing and Discussions***
- ***Primer for Planning for Engagement with Important Science Ideas***
- ***Tool for Planning for Engagement with Big Science Ideas***

Reflect

- What is Crystal Cove Conservancy's model for a community science education program?
- What are some of the educational best practices that we use when designing educational programs?
- What will you need to do next to design your own community science education program?

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Choosing an Audience

Steps to Planning an Education Program

The age and demographics of your audience will have a big effect on your program.

As you begin deciding how to develop the educational framing around your community science program, one of your first decisions will involve choosing your audience. Your audience could be a specific teacher and their students, a K-12 grade level, an after-school group, families in your community, or another type of group entirely.

Different groups of students bring different perspectives, past experiences, and other assets to a learning experience that are important to keep in mind as you design your program. Learners are also capable of different things at different ages. The age of your participants will impact the types of learning outcomes that you want to achieve or how you might choose to have them collect and analyze data.

What You Will Do

As you read through this guide, you'll learn about some different considerations that we keep in mind when we choose an audience for our community science programs. You'll also get an introduction to a needs assessment, and then explore how you might identify the assets and funds of knowledge that your audience might bring to your educational program

By the end of this guide, you'll be ready to choose an audience for your program!

By the end of this guide, you will be able to...

- Describe different considerations to keep in mind when selecting an audience.
- Choose your audience.
- Come up with a plan to determine your audience's assets and funds of knowledge.

Getting Started

When we begin designing an educational program based on a community science project, we usually start by making two decisions: 1) Deciding on the audience that we want to work with for the educational program; and 2) Deciding how we want to adapt our research question for the educational program.

These decisions do not need to be made in a particular order. Sometimes, the research question comes first: we know that we want to investigate a particular research topic or question, and so we'll use that to guide our decision about which learners to focus on. Sometimes, we make the decision in reverse: we start off knowing that we want to work with a particular class or grade level, and so we develop a research question that is developmentally appropriate for that age.

As you read through this guide, you can decide what makes the most sense for your program and make these two decisions in the order that matches your needs.

Conduct a Needs Assessment

A needs assessment is a process for determining the needs and gaps related to a particular question or new initiative. When you're getting started with selecting an audience or designing a program, instead of assuming you know what teachers and school districts need and want from an MPA program, it is helpful to conduct a needs assessment.

See the ***Needs Assessment*** section earlier in this guide for details about how to conduct a needs assessment.

Investigate State Standards

Each state, including California, has specific state standards for K-12 schools that tell school districts and teachers what students should learn in different subjects by the end of a particular grade. These standards drive what teachers are required to teach in the classroom. Students are then tested on their knowledge and skills at different points in their schooling career.

As you're starting to think about what grade to work with, it's important to be aware of the state standards for that grade level. These standards will give you an idea of what students at each grade are expected to do and learn, both in regards to collecting and analyzing data as well as learning about other topics. If your program aligns well with state standards, it will also make it more likely that teachers will want to participate in your program, and that they'll be able to get permission from their school or district to join you on a field trip.

One final note on aligning with state standards: It is usually better to choose a few standards to address in depth, rather than try to list everything you possibly can. Typically, depth is considered better than breadth, especially in regards to Next Generation Science Standards.

Next Generation Science Standards

With all grade levels, the ***Next Generation Science Standards*** (NGSS) will play an important role in ensuring that your program will meet the needs of your audience. The NGSS describe what students need to know or be able to do regarding science content at different grade levels.

The NGSS are noteworthy for schools because they have caused a shift in how science is taught. These new standards are different from old science content standards in California because they call for a three-dimensional approach that mimics how professional scientists develop new science knowledge, integrating Disciplinary Core Ideas, Crosscutting Concepts, and Science and Engineering Practices. This is very different from old California science content standards, which mostly focused on having students memorize facts.

If you aren't already familiar with them, it's worth visiting the ***Next Generation Science Standards website*** to learn more about their three-dimensional approach to science learning.

Our model for MPA community science programs naturally aligns with this three-dimensional approach. As students engage in community science research that focuses on a specific disciplinary core idea, they utilize science practices to plan and carry out investigations. Our programmatic approach frames science investigation through the Crosscutting Concept lens of Systems & Systems Models, challenging students to think about the visible and invisible interactions that affect environmental systems in an MPA. There is also tight alignment with the NGSS Science & Engineering Practices, which involve practices such as asking questions, developing and using models, and analyzing data.

As you review the standards for your audience's possible grade level, pay attention to Life Science standards that address ecosystems. Connecting ecosystems and human activity within your program may also allow you to address Earth and Space Science standards.

Common Core Standards

Many states have adopted the ***Common Core Mathematics Standards*** and ***Common Core English-Language Arts Standards***, which define what students should learn in math and language arts. You can check to see if your state has done so ***on their website***. If you are in California, you can also view ***California's version of the Common Core State Standards*** online.

Common Core Math Standards are helpful to review as you think about how you want students to collect and analyze data. For Grades K-5, the Measurement and Data standards will give you an idea of what students are expected to be able to do at different grade levels. In middle school and high school, Statistics and Probability standards are appropriate for a program.

Common Core English-Language Arts Standards will give you guidelines on what students should learn related to communicating and presenting ideas. If you choose to have your students share their findings at the end of their community science project, it will be helpful to review the Presentation of Knowledge & Ideas standards for your audience's grade level.

Computer Science Standards

California recently adopted ***computer science standards*** for K-12 grade levels. An MPA community science program can be used to help students put the Data and Analysis core concepts into practice in an authentic setting as students analyze data.

If you don't live in California, you can refer to the ***K-12 Computer Science Framework*** for guidelines to help you incorporate computer science into your program.

Decide on a Grade Level Band

As children develop and grow, they develop increasingly complex reasoning and motor skills, which allows them to take part in increasingly complex activities related to data collection and data analysis. As you're deciding which grade level you want to work with, it is also helpful to keep in mind what students are typically capable of at different grade levels.

Lower Elementary (Grades K-2)

- Cognitively, lower elementary students are learning to do data analysis tasks such as counting and sorting. They work best dealing with physical data (such as collecting physical samples of trash or counting shells).
- Lower elementary students are still developing their fine motor skills, so they may need extra help using a ruler or manipulating scientific equipment.
- Safety is an important aspect for all programs, but especially for K-3 students. You may not want to bring them on a boat or somewhere with uneven terrain.
- Younger children have a very short attention span. Keep in mind the appropriate duration of a lesson for this age group and keep it to 20-30 minutes at a maximum.
- Often, elementary schools will want to bring their entire grade level on a field trip, and they usually like to send at least two classes at a time. Depending on how big the school is, this may mean that you will have to be prepared for groups of 60 or more at once.

Upper Elementary (Grades 3-5)

- Upper elementary students are continuing to develop their cognitive skills. In school, they're learning to create simple bar or line graphs that compare two or three different categories. They may also be learning about statistical means of center, such as finding the mean or average.
- Physically, upper elementary students are learning to measure objects and can follow instructions to manipulate equipment. However, they may still struggle with fine motor skills and may need some extra check-ins.
- Be aware that the time available to teach science is usually limited in upper elementary classes. Typically, we find that classes only have 30-45 minutes available for science lessons at a time, with maybe 2-3 science lessons throughout a week.
- Often, elementary schools will want to bring their entire grade level on a field trip, and they usually like to send at least two classes at a time. Depending on how big the school is, this may mean that you will have to be prepared for groups of 60 or more at once.

Middle School

- Middle school students are capable of taking on more complex graphs and models. They have also likely been introduced to simple statistics, such as finding the mean, median, and standard deviation.
- Middle school students have more refined motor skills and are more adept at manipulating equipment. However, be aware that there is often a big difference in student heights as they hit their growth spurts at different times. (Which sounds silly to think about, but can affect students' ability to use equipment!)
- Schedules at middle schools can lead to restrictions on time, so be aware that class periods may only be 45 minutes in length. This may require in-class lessons to be broken up and spread out over multiple class meetings.
- Like elementary schools, middle schools often want to send their entire grade level on a field trip. Some middle schools are particularly large, so this is something you may want to discuss with the school or teacher in advance.

High School

- High school students are capable of complex data collection methods and tools, and have likely been introduced to basic statistics, such as finding the mean, median, and standard deviation.
- Schedules vary a lot between different high schools. Some high schools use block scheduling with 90-minute classes, while others might only have 50-minute classes. This can lead to restrictions on time, so make sure to understand the needs of your high school teachers for in-class lessons and field trips.
- High school science classes are often specialized and focus on one or two subjects. For example, an environmental science class will have a different focus than a marine biology or biology class.
- High school teachers often want to bring all of their classes in a similar subject on a field trip. For electives like marine biology or AP Environmental Science, this may be two or three classes total (although it could be much more for classes that every student is required to take, such as Biology).

Consider Non-Traditional Groups

Schools are not the only groups that may be interested in helping you pilot an MPA community science program. Other non-traditional groups could include YMCA or other after-school programs, Boy Scouts or Girl Scouts, summer camps, Tribal groups, families, or more.

If you are interested in expanding your reach to non-traditional groups you haven't partnered with in the past, here are some tips for reaching out to them.

- Spend some time reviewing the organization's website (if they have one) and getting to know their goals for participants.
- Take a look at the state content standards for the age group of their participants. Even if the group isn't interested in academic outcomes, the standards will still give you an idea of the cognitive level of participants at different ages.
- Put together basic information about your organization, your program, and what you want to accomplish, and then reach out to schedule a meeting.

Be prepared to ask questions similar to a needs assessment, such as:

- What do you or your organization want to get out of a program like this?
- What kind of participants do you usually work with? What's their motivation for being involved with your organization?
- How do you envision things working logistically? Do you have staff or volunteers who would be able to help teach parts of the program, with or without training?
- What are the safety requirements that you might have for our organization? Does our team need to get background checks?

Research Project Equipment Considerations

As you're deciding which age group to work with, you may also want to consider the scientific equipment that is necessary for the research project you are conducting in your local MPA.

If your project requires the use of complex sampling equipment, such as a van Dorn bottle to collect water samples at different depths, you will likely want to work with older students who are capable of operating such equipment.

Projects that require simple equipment or are based solely on observations done without equipment can be accomplished with a wider range of age groups. If the sample collection and analysis is simple, the data analysis component can be designed to be more complex to meet the needs of older students.

Assessing Your Audience's Assets & Funds of Knowledge

Once you've selected an audience, it's helpful to spend some time thinking about what knowledge and experiences they might bring to the program.

In education, we often talk about funds of knowledge, or the family and cultural knowledge and experiences that learners bring with them. Even if they have not been to an MPA before, many students have their own unique connection to nature, whether it's visiting a park near their home with their family, going fishing with a relative, tending a garden, or watching nature videos. They may have gone to the beach with their family, or might have an older relative who has shared cultural knowledge of how to cook with certain plants.

As you explore your participants' likely past experiences, we also think it's extremely important to focus on the assets that they bring to your program. Rather than describing them in terms of what they don't have (i.e., using a deficit-based model), make sure to focus on what they can do: their strengths, cultural knowledge, curiosity, interests, enthusiasm, and skills.

You can learn about your participants' assets and funds of knowledge in different ways. If you're working with a school group or other organized group, you can ask the teacher or group leader to answer questions. You could ask students to share about themselves by writing a letter, putting together a short photo essay, or filming a short video. You could also take time to get to know their community and attend public events there.

Some questions to think about:

- How would you describe the students?
- How old are they? What might they be interested in?
- What cultures might they generally belong to? What languages do they speak at home?
- What kind of science learning experiences have they had access to in the past?
- What outdoor spaces might they be familiar with?
- What assets do they bring to the program? What could you learn from them?

As you're designing your program, we've found that it is extremely helpful to include members from our audience's community on our design team or as an advisory group. Be prepared to pay small stipends in return for your advisors' expertise and community knowledge.

Resources

- More information about ***Asset-Based Pedagogies*** from the CA Department of Education
- ***Next Generation Science Standards***
- ***Common Core Mathematics Standards***
- ***Common Core English-Language Arts Standards***
- ***K-12 Computer Science Framework***

Reflect

- What will you keep in mind as you select your audience?
- What audience will you focus on?
- What assets and funds of knowledge are they likely to bring to your program? If you don't know this, how can you find out?

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Adapting Your Research Question

Steps to Planning an Education Program

Community science is all about answering ecological questions!

If you already manage a community science project based in a Marine Protected Area, you likely have a well-developed research or monitoring question to guide your work. You might be monitoring ecological changes over time, observing and recording different types of human activity, or comparing differences in marine populations in different places within the MPA.

The research question that students investigate informs the type of data that they will collect and the approaches they'll use in analyzing that data. If the research question associated with your community science project is complicated, you may want to think about creating a scaffolded version of it that is specific to your community science education program so that the data analysis strategies are friendly for students.

What You Will Do

As you read through this guide, you'll learn about some of the different considerations that we keep in mind as we develop a scaffolded version of our research questions for students. You'll also reflect on how the design of your research question might inform data collection and data analysis for your audience.

By the end of this guide, you'll be ready to adapt your research question for students!

By the end of this guide, you will be able to...

- Reflect on how your research question drives data collection and data analysis for your participants.
- Develop a student-friendly research question that is appropriate for your audience.

Getting Started

When we first begin designing an educational program based on a community science project, we often start by thinking about how to adapt our research question for students. Different types of data analysis are developmentally appropriate for different age groups, so it is important to consider our audience and our research question together.

As mentioned in the ***Choosing Your Audience*** guide, adapting your research question can happen before or after you decide what audience you want to serve. If you want to work with a particular age range of students, that may drive the scaffolded research question that you develop. Conversely, if you are set on having students investigate a particular research question, you may want to choose an audience that can handle the data analysis approaches required by that research question.

What This Looks Like in Practice

It is important to note that adapting and simplifying a research question does not change the type of data that students collect. They can still contribute to your larger MPA community science project. Adapting a research question simply frames what they'll look at in terms of data analysis.

No matter the age group, we usually recommend having student research teams look at one or two research questions at most. If your study involves more than two research questions, or if it involves analyzing data for multiple types of conditions, you may want to consider dividing up the student teams and having different teams analyze different questions.

For example, Crystal Cove Conservancy partners with UC Irvine to run a land-based community science project that is investigating how different restoration strategies affect the growth of native plants over time. Because that program is intended for an audience of fifth grade students, we adapted the overarching research question so that the resulting data analysis would be more developmentally appropriate.

Original Research Question	***Scaffolded Research Question***
How does mulch affect the growth of native seedlings over time?	Where do seedlings grow taller: in plots with or without mulch?

To answer the original research question, we'd have to look at change over time. The scaffolded research question allows us to compare seedling growth on a single day (ideally, at the end of the growing season). Graphing a data set over time might be challenging for fifth graders, but they can capably graph and compare the mean of two different groups of numbers.

What Students Learn at Different Grades

As you begin to think about how to adapt your research question, it's helpful to start by reflecting on what students can know and do at different age levels.

As mentioned in the ***Choosing Your Audience*** guide, each grade level has specific Common Core Math standards, which will give you an idea of what students are expected to learn or do related to data collection and analysis at different ages. In Grades K-5, these are called Measurement and Data standards. In middle school and high school, they're referred to as Statistics and Probability standards.

Once you decide what grade level you want to work with, we highly recommend looking at the standards for that grade so that you can get a sense of what students are expected to do with data and graphing at that age.

These standards are available ***on the Common Core Math website***.

Types of Research Questions

There are a few different types of research questions that you might choose to use for your program. These include:

- **Classifying Observations:** A research project focused on classification might involve making observations or collecting physical samples. This type of research project usually works best with younger students in lower or upper elementary grades. Once data is collected, students might sort their observations or samples into categories or create a bar graph comparing the total number of objects in each category.
- **Comparing Different Conditions:** This type of research design might involve an observational study or an experiment where students compare data for two or three different treatments. It is important to note that as of January 2021, the California Department of Fish & Wildlife is not allowing manipulative experiments inside MPAs, and you will need a permit for experiments conducted in other places!

  This type of research question pairs well with students in upper elementary, middle, and high school. Once data is collected, students might calculate the mean of each treatment and then compare them using a bar graph.
- **Analyzing Change Over Time:** This research design might be set up as an observational study that takes place over several months or years. We've found it works well for middle or high school students. Once data is collected, students might create a line graph or scatter plot to look for patterns over time.
- **Mapping Spatial Distribution of Data:** This research design involves collecting the GPS coordinates of observations within a particular space. We've found it works best for middle or high school students, but it could also be adapted for upper elementary. Once data is collected, students might create a GIS map with different layers to show how data is distributed spatially.

On the next page, you'll find a chart that gives examples of each different type of research question, the age groups that work best with each category, and a summary of how each category of research question might inform your research design, data collection, and data analysis. You can also find guidance on writing science research questions in the documents linked in the ***Resources*** section below.

Research Question Categories	Age Groups	Example Research Questions	Research Design	Date Collection Approaches	Data Analysis Approaches
Classifying Observations	Lower Elementary	What is the most common type of trash on the beach of your local MPA?	The research design might be simplified to only look at one physical sample.	Collecting physical samples	Sort samples into simple categories and count the number in each category.
	Upper Elementary	How many total species of birds are on the beach in the summer and winter in your local MPA?	The research design might include ideas about randomization or contributing to a larger data set.	Make observations or collect samples	Sort samples or observations into categories. Create a bar graph comparing the total number for each category.
Comparing Different Conditions	Upper Elementary, Middle, or High School	If we measure the size of owl limpets in tidepools with lots of visitors and tidepools with few visitors, where will they be bigger?	The research design could be set up as an observational study with different treatments. It could also be a randomized experiment (though CDFW currently does not allow these inside MPAs in California).	Make observations or take measurements	Calculate the mean or median to represent a group of numbers. Create a bar graph to compare means or medians. Use standard deviation to look at statistical distribution.
Analyzing Change Over Time	Middle or High School	How is the total number of fish species in our local MPA changing over time? If we compare the number of fish species in our local MPA to an area outside the MPA, how are they changing over time?	The research design can be set up as an ongoing observational study over months or years. It might involve comparing different treatments, such as comparing different places.	Make observations or take measurements	Create a line graph to look at change over time. Create a scatter plot and add a line of best fit to look at the trend over time. Calculate R^2 value to think about statistical variability.
Mapping Spatial Distribution of Data	Middle or High School	Where are human activities concentrated in our local MPA at different times of year? Where are the most fish present in relation to local MPA boundaries?	The research design might involve making observations within a particular place, or comparing different treatments, such as comparing different habitats or times of year.	Take GPS points of observations.	Calculate distance between GPS points and another location (like an MPA boundary). Create a GIS map showing the spatial distribution of data. The map may involve different-colored layers to compare different treatments or categories.

Adapting Your Research Question

When you're ready to begin adapting your research question for your audience, try responding to the questions below.

- What is the current research or monitoring question for your MPA community science project?
- What is the age group of your audience? What type of research question is most developmentally appropriate for them?
- Do you need to adapt your current question? If yes, how might you adapt your research question for your audience?
- If your community science project monitors several different factors, are there one or two that you want students to focus on? If there are more, can you develop similar research questions for different student teams to look at?

Resources

- *How to Write a Science Research Question*
- *Field Investigations: Using Outdoor Environments to Foster Student Learning of Scientific Processes*

Reflect

- What. will you need to think about as you adapt your research question for students?
- How can you adapt your research question to make it appropriate for your audience?

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Deciding on Logistics

Steps to Planning an Education Program

Any program manager knows that logistics matter.

As you develop your MPA education program, you will need to make some decisions regarding the logistics of how your program will operate. These decisions should be made in an intentional manner in order to ensure that they support the educators and students who will be participating in your program. They will also be dependent on the specific location where you run your community science program and the needs and preferences of the educators who are participating in your program.

What You Will Do

As you read through this guide, you'll learn about decisions that you will need to make regarding the logistics of your program. These decisions include who will teach your program and the location of the lessons. You will also learn about some decisions that need to be made regarding research teams, field notebooks, and educational technology.

By the end of this guide, you'll be ready to decide on the logistics for your educational program!

By the end of this guide, you will be able to...

- Decide where and when lessons will take place.
- Decide who will teach your program.
- Make decisions about other program logistics, including integrating research teams, field notebooks, and educational technology.

Deciding Where and When Lessons Will Take Place

One of the first logistical decisions you will need to make is where and when the lessons for your program will take place. The audience and research question for your program will play a role in determining the location.

Some sessions are a natural fit for taking place in the field and some can take place in a classroom or an informal education setting such as a YMCA building. ***Session 1: Asking Questions*** and ***Session 4: Collecting Data*** should be prioritized for taking place in the field. If necessary, Session 1 could be done as a virtual field trip to get the students familiar with the data collection location.

If you are working with classroom teachers, the other sessions could be implemented in their classrooms. If you are working with another type of group, such as a YMCA or a summer camp, you will need an indoor space where the other sessions can take place where the students will have access to the technology and other resources that are necessary for each session.

It is also important to consider the time of day for the lessons. For field trip sessions, make sure to talk with the teacher or leader of the group to get an understanding of the logistical restrictions they might have regarding the time of day for field trips and the duration of field trips. Many school districts have time restrictions due to bus schedules that they must adhere to for all field trips. After school clubs may also have time restrictions for when they can go on field trips or meet at the school. This varies between schools and for age groups, so it is important to talk with the teacher or group leader to understand their needs.

Other types of groups such as summer camps, Tribal groups, or scout groups will also have logistical restrictions on when they can meet, so it is important to talk with them about the details early in the planning process.

Deciding Who Will Teach Your Program

We designed our MPA Exploration for Crystal Cove Conservancy staff members to teach the field-based sessions and for classroom teachers to teach the other sessions. You may find a different arrangement will work for you depending on your audience. For instance, especially during your first test program, you may want you or your staff to teach all of the sessions for the program to get a feeling for what works or doesn't work.

It is important to talk with the teacher or group leader you are working with to get an idea of their comfort level with engaging with real science practice. Many classroom teachers and group leaders from informal settings do not have experience in facilitating real research projects where they do not know the answer in advance. They may not feel comfortable with teaching any of the classroom-based sessions or they may need some training to prepare them to teach the program.

Some topics to discuss with the teacher or group leader include their comfort level with teaching science, using technology, safety in the field, and interacting with students in a lesson-based setting. If they are not comfortable with certain areas, your staff members may need to provide additional scaffolding in the form of videos, join them to teach certain sessions, or provide professional development workshops to help them gain the knowledge and skills they need to successfully teach the sessions.

Integrating Research Teams

Just like a lot of things in life, science is really a team endeavor. It's rare to find one scientist working all by themselves on a research project. More frequently, you'll find teams of scientists, each of whom might come from a different background and specialize in a different topic. Incorporating different perspectives and skills makes the work that we do even stronger.

Since your community science program is meant to give students an authentic science experience, we suggest that students work in research teams of 3-4 students. Working in research teams also gives students a chance to talk and negotiate their understanding out loud.

If you choose to have students work in research teams, we recommend establishing these teams in ***Session 1: Asking Questions*** and then having students stay in the same teams for the entire unit.

Integrating Field Notebooks

Throughout the MPA Exploration, students are encouraged to use field notebooks to take notes, record observations, plan investigations, and reflect on their own thinking. Science notebooking is considered a best practice in science education. Having their own personal science or field notebook allows students to draw models or record observations about what they think is happening, take notes, plan investigations, and reflect on their own thinking. It also gives them a clear record of what they've done that they can look back on at the end of the program.

Before beginning the program, we recommend thinking through the logistics of the field notebooks.

Ideally, especially if you are working with middle or high school students, your field notebooks should be free-form, blank notebooks. Using blank notebooks allows students to structure their thinking as they go and gives them a sense of ownership over the process.

We do provide an option of pre-designed journals for our teachers, although we encourage them strongly to use blank notebooks if they can. We've found that some teachers prefer virtual notebooks that they can easily view. Some schools in low-income areas might also prefer to print their own field notebooks so that students are not required to purchase their own (although this can be circumvented by providing them to participating schools).

It is important to note that although field notebooks can give you a window into how student understanding is evolving, they are not intended as a summative assessment tool. We advise our teachers not to grade their students' field notebooks. Instead, we recommend giving students a chance to publish their thinking at the end of the program.

If you're interested in learning more about notebooking, we've included some resources at the end of this guide!

Integrating Technology

There are a variety of technological platforms that are available to support learning throughout your program. They can be used for sharing information, exploring an MPA virtually, creating models, analyzing data, and designing communications.

Before you start designing your program, you should consider which platforms you might want to use. We recommend limiting the number of new technological platforms that you introduce to students, as learning to use too many new technological tools can be overwhelming.

We've included a few of our favorite technological platforms below!

Sharing Information

- ***Google Slides*** is a free platform that is similar to Microsoft PowerPoint, and you can embed videos into the presentations from a YouTube account. Due to school permissions, teachers will likely need to make a copy of each Google Slides presentation on their school Google account so that students can access it.
- ***VoiceThread*** is another option for slide presentations that allows you to easily embed videos or only narrations into the slides. It is free for students and teachers to view presentations, but there is a fee to obtain a license to create VoiceThread presentations.
- ***Flipgrid*** is a free platform that allows students to film and share short videos in response to a prompt. It is a great tool for responding to reflection questions, especially for younger students.

Exploring an MPA Virtually

- ***ThingLink*** is an easy-to-use platform that allows organizations to create interactive photo maps that users can click on and explore -- including 360-degree photos.There are a range of pricing options for the organization that creates the interactive photo map.

  It is easy for teachers to use in the classroom because all they need to be able to do is demonstrate how to access virtual explorations and show students how to click through them. During our MPA Exploration program, students use ThingLink to take a virtual tour of the Crystal Cove SMCA in ***Session 1: Asking Questions***, and then have the option to visit another ThingLink later in ***Session 6: Collecting Data*** to participate in a virtual monitoring cruise, if they cannot take part in an in-person field trip.

Creating Models

- ***Padlet*** is a collaboration platform similar to an online bulletin board, which will let multiple students collaborate and build a model at the same time. Free accounts (which students can sign up for) can create up to three Padlet boards. Pro accounts, which let a user create unlimited boards, start at $8/month. If you don't have access to Padlet but prefer a collaborative option for modeling, you might consider using *Google Jamboard* or another online collaborative whiteboard instead.

- ***SageModeler*** is a free, online modeling tool that can be used to build computer simulations of systems. Although it is challenging to collaborate on SageModeler because only one person can manipulate the model, this platform will also allow students to easily define computational relationships between different factors in their models and simulate how environmental change will affect them.

Analyzing Data

- ***SageModeler*** has the ability to create graphs and display data using visualizations that are deliberately designed to help students think about data distribution and outliers. This can help students to build a conceptual understanding of ideas like statistical significance. It is also easy to use, which makes it ideal for younger students. However, it is challenging to collaborate on SageModeler because only one person at a time can manipulate it, and it is not a platform that would be used by practicing researchers.

- ***Google Sheets*** is a more traditional data analysis platform that is very similar to Microsoft Excel. It allows students greater freedom in creating graphs and performing calculations, and it can also be accessed collaboratively, with multiple students working on the same document in real time. However, using Google Sheets requires students to be more attentive to the step-by- step process involved in creating graphs and performing calculations, which can detract from conceptual understanding.

Designing Communications

- If you plan to ask students to create a social media piece to communicate ideas about your local MPA, there are several options they can use to design, produce, and share their social media piece. Teachers may have graphic design and video editing programs that they already use. If not, easy-to-use, free Mac & PC options include ***Krita*** for graphic design and ***Da Vinci Resolve*** for video editing. Mobile options include ***Adobe Lightroom*** for image editing and design, and ***InShot*** for video editing.

Resources

- *Setting Up Your Science Notebooks*
- *How to Keep a Lab Notebook*

Reflect

- Who will teach your program?
- When and where will each session take place?
- Will you use research teams?
- Will students use field notebooks? Where will they get them? What format will they be in?
- Which technology platforms might you integrate into your program?

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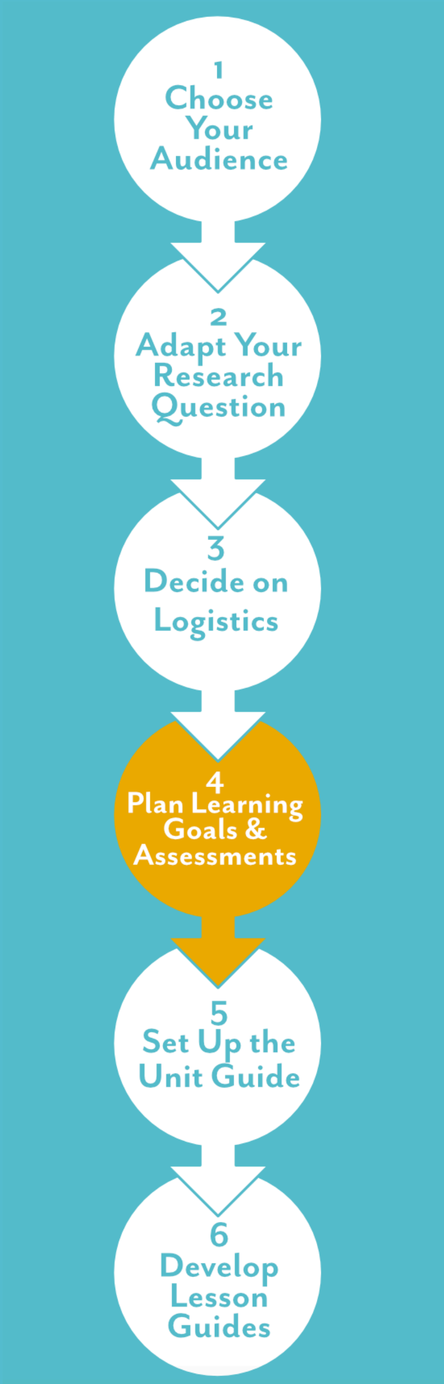
Planning Learning Goals & Assessments

Steps to Planning an Education Program



Learning outcomes describe what students will be able to think, know, or do at the end of a learning experience.

As you begin developing your own MPA community science educational program, you'll need to develop learning goals for your unit that describe the big picture concepts that students will master throughout all of the sessions. In addition, you'll also develop specific learning objectives for each individual session.

To determine whether or not students are meeting your learning outcomes and learning objectives, you'll also need to plan how to assess their progress. Although we often think of assessment of being summative, like a test at the end of a unit, a lot of classroom assessment happens along the way as students take part in conversations or record their thoughts in their field notebooks. These embedded assessments can help you and other educators monitor what students are learning and where they might be confused.

What You Will Do

As you read through this guide, you'll learn about the role learning outcomes, learning objectives and assessments play in an MPA community science educational program. You will explore how to develop learning outcomes, learning objectives, and assessments, and begin developing learning outcomes and summative assessments for your unit.

By the end of this guide, you'll be ready to begin designing learning outcomes, learning objectives, and assessments for your own MPA community science program!

By the end of this guide, you will be able to...

- Reflect on how learning outcomes, learning objectives, and assessments support student learning.
- Begin planning learning outcomes and summative assessments for your program.

Using Backwards Design

Developing learning outcome statements and assessments is an important part of the educational design process. When we begin designing a new program, we use a process called Backwards Design, where we start by developing learning outcomes and assessments and then plan the activities from there.

Going through this process -- deciding what we want students to learn first, and then using that to plan activities -- helps guide the development of the program so that we can be sure that students will learn what we want them to.

Types of Learning

When you decided to create an educational program for students, you probably had specific things that you wanted them to learn or do as a result of your efforts. Perhaps you wanted participants to take action to help protect your local MPA. Maybe you wanted them to learn more about the ecosystem there, or to develop a stronger understanding of how to do scientific tasks like collecting data or using evidence to support their claims. You may have even wanted them to feel more excited and connected to the outdoors after taking part in your program.

There are many different ways that a science learning experience can affect a student. The National Academy of Science's ***Learning Science in Informal Environments: People, Places, and Pursuits*** (2009) groups possible learning outcomes into six categories, which they call the Six Strands of Informal Science Learning:

- **Strand 1:** Developing an interest in science
- **Strand 2:** Understanding science knowledge
- **Strand 3:** Engaging in scientific reasoning
- **Strand 4:** Reflecting on the process of science
- **Strand 5:** Engaging in science practice
- **Strand 6:** Identifying as part of the scientific enterprise

Community science educational programs, which let students take part in scaffolded scientific research focused on a local place, can produce all six different types of learning. As you begin reflecting on what students will learn from your program, we recommend considering possible learning outcomes from all six of these groups.

Our Terminology

For the purpose of this guide, as we discuss learning outcomes, learning objectives, and assessments, we define these terms in specific ways.

- **Learning outcomes** are what we measure at the end of the entire program or unit. These are the biggest ideas that you want students to walk away with at the end of the program. They often have to do with big changes to student thinking, such as changes in interest, motivation, understanding of big concepts, or reflection on the practice of science.

  Since students achieve these learning outcomes over the course of the entire program, we'll often include 8-12 learning outcomes.

- **Learning objectives** are measured at the end of each lesson. They are often more specific, focusing on specific skills or knowledge that students might acquire, or reflecting on a very specific part of science practice. We always try to write learning objectives in a way that can be measured, so we use words like "explain" or "reflect" (which we can observe students doing) instead of "understand."

  We usually try to stick to keep our learning objectives more limited, with no more than 3-5 per session.

- **Summative assessments** take place at the end of a unit or learning experience to measure the totality of what students have learned. We try to pair each learning outcome with a summative assessment so that we can determine whether the program is having the desired impact on students.

  Often, for our summative assessments, we develop a rubric that is used to score a presentation or final published project. We also use pre- and post-program surveys to measure changes in student interest, understanding, and attitudes.

- **Formative assessments** are used to monitor learning throughout the program. They are a tool used to inform educators about how student understanding is developing throughout the program. If students aren't developing the desired knowledge or skills, then formative assessments can reveal that to the educator, making it possible to correct their course.

  We always make sure to pair our learning objectives for each session with a formative assessment strategy. These could involve what students say during discussions, what they write in their field notebooks, or the products that they produce (such as their models).

Planning for Engagement with Big Ideas

Our commitment to science-as-practice means that we give students the opportunity to engage with the big ideas of science. The big ideas of science are not just a list of facts, but are foundational scientific concepts that describe relationships between factors and can be used to explain other scientific topics and concepts.

It is challenging for students to engage with big ideas, so as you're beginning to think about what you want students to do or learn during your unit, it's helpful to plan carefully for how your program will set students up for success.

The book ***Ambitious Science Teaching*** provides a roadmap for how to plan for engagement with big ideas that includes three steps:

1. Identify a big idea based on NGSS or state standards
2. Choose an anchoring event that relates to the big idea and is meaningful to students and develop a detailed explanation of that event
3. Organize a series of learning experiences that allow students to build knowledge and skills to answer essential questions related to the anchoring event

The ***Tools for Ambitious Science Teaching website*** provides details on these three steps to help educators develop a big idea, an anchoring event and explanation, essential questions, and a series of learning experiences. Although it takes time to use, it is a really helpful tool that will assist you in planning to engage students with big ideas that relate to your local MPA. The ***STEM Teaching Tools*** website also has a resource that describes the qualities of an effective anchor phenomenon.

Before you move on to developing learning outcomes, take a few minutes to consider:

- What is the big science idea that you want students to understand by the end of the entire program?
- What are students likely to know already about your big science idea? Why might they be interested in it? How could it connect with their own experiences?
- How could you introduce this big science idea at the start of the program? What could students look at or explore to introduce them to the situation?

Identifying Links to Content Standards

Once you've identified your big idea, it's helpful to revisit the Content Standards for your audience to look for possible links. These will likely include Next Generation Science Standards, but could also involve Common Core Mathematics, Common Core English/Language Arts, or Computer Science Standards.

As you review the standards again, identify any key links to your big idea. You'll want to make sure that the learning outcomes you develop match the language in these standards as closely as possible.

Getting Familiar with Bloom's Taxonomy

Once we've identified our big idea and links to standards, we're ready to move on to developing learning outcomes and learning objectives. To do this, we rely a lot on Bloom's Taxonomy. Bloom's Taxonomy includes lists of verbs (e.g., describe, list, interpret, critique, produce, identify, reflect) that can be used in learning objective statements that are observable, which makes it possible for educators to assess if students have met the outcomes or objectives.

If you're not already familiar with Bloom's Taxonomy, Iowa State University has a helpful ***website*** that describes how it works.

Developing Learning Outcomes

Learning outcomes should capture what students will come to understand or how they will change throughout the entire unit. They are usually related to the biggest ideas in our program, and may align with Performance Expectations from the Next Generation Science Standards.

We often try to have learning outcomes that align with each of the Six Strands of Informal Science Learning: Developing an interest in science, understanding science knowledge, engaging in scientific reasoning, reflecting on the process of science, engaging in science practice, and identifying as part of the scientific enterprise.

As we begin developing our programs, we like to list our learning outcomes and assessments in a table to make it easier for educators to see the connection between the two. You can see some examples of learning outcomes and summative assessments.

By the end of this module, students will be able to...	*You can assess this using...*
1. ***Express*** interest and excitement about taking part in community science research.	Pre- and post-program surveys
2. ***Understand*** how MPA regulations help to protect coastal marine ecosystems.	Observations of student discussions and science journals
3. ***Use*** their model and data visualizations as evidence to support a claim about [how MPA regulations and changes to the environment may affect fish populations in a coastal marine ecosystem].	Research team final products or presentations, graded with a rubric
4. ***Reflect*** on how science knowledge is generated and how that knowledge plays a role in [protecting coastal ecosystems].	Student reflections at the end of the program
5. ***Participate*** productively in scientific practices and the discourse of science, such as constructing a visual model of a marine ecosystem, following protocols to collect data, and constructing a data visualization.	Observations of student discussions and products throughout the program
6. ***Express*** an increased sense that they are able to contribute to the generation of scientific knowledge or protecting the environment.	Pre- and post-program surveys

Planning Summative Assessments

In addition to developing learning outcomes for your unit, you'll also want to plan how to assess them. Summative assessments are used at the end of a learning experience to determine how that experience impacted students.

Oftentimes, we're usually more interested in assessing the impact of our program than giving students a letter grade. As a result, rather than giving students a quiz, we try to embed our summative assessments so that they're the natural product of student participation in the program. We might assess student reflections, observe their discussions throughout the program, or use pre- and post-program surveys. For teachers who do want to score students for grading purposes, we'll develop a rubric to assess the final presentation or product. (More on that in the ***Session 6: Sharing Your Findings*** lesson guide.)

If you're reporting to a funder, you may also want to conduct a summative assessment in order to evaluate the program's effectiveness and measure its impact on students. As much as possible, we try to use survey tools and measures that have been developed and tested by other researchers. These measures are often designed to measure specific types of program impacts on specific age groups.

Some survey measures that you might want to use include:

- The Cornell Lab of Ornithology has developed a toolkit for measuring outcomes in community science programs. You can review their list of instruments and submit a request to use them at this ***website***.
- The ***PEAR Institute*** has a searchable database of assessment tools that includes descriptions and reviews of tools that can be used to measure performance in out-of-school programs.
- If you would like more information about using assessment instruments, ***InformalScience.org*** has a page that provides helpful information and links to additional resources.

In the MPA Exploration, Crystal Cove Conservancy has developed pre-program and post-program assessments. We have found that using Google Docs makes it easy for educators to implement the assessments. You can see our assessments at the links below.

- ***Pre-Assessment***
- ***Post-Assessment***

Developing Learning Objectives

In addition to the learning outcomes for your entire unit, you'll also need to develop learning objectives for each session. We usually develop these as we work on each session, but we always check in and make sure that they lead to our broader learning outcomes.

Learning objectives should be specific and measurable. Ideally, they describe an action that students will be able to demonstrate that indicates their knowledge, skills, attitudes, and behaviors.

Like with learning outcomes, it is helpful to refer to the NGSS when developing learning objectives to ensure your objectives align with what students are expected to be able to do at their grade level. In the MPA Exploration, we have found that "reflect" is a particularly helpful word to use in learning objectives because it allows students to think about the process of science and why scientists use the tools that they use and students can document their reflections in a science notebook.

There are websites that can assist you in the process of creating learning objectives:

- ***Learning Objectives Builder*** from Arizona State University
- ***Learning Objectives Maker*** from easygenerator.com
- ***Developing Student Learning Outcome Statements*** from Georgia Tech

Planning Embedded Formative Assessments

Just like our learning outcomes and summative assessments, we pair each learning objective with an assessment as well. These are usually formative assessments that are embedded within the session.

Types of embedded assessments that work well with community science programs include discussions, science notebooks, personal reflections, and student-created products such as a model of an ecosystem.

When you're planning embedded assessments, it's helpful to consider what success might look like. What will students do, say, or produce if they achieve the learning objective that you've set out? What will it look like if they don't? Are there any signs you might watch out for to see if they're struggling?

Developing Learning Outcomes & Summative Assessments for Your Program

Now that you've read a bit about learning outcomes and assessments, take time to think about what you want students to understand or be able to do at the end of your program.

What learning outcomes might you create? How could you assess them at the end of your program?

Resources

- ***User's Guide for Evaluating Learning Outcomes from Citizen Science***
    - ***Interactive User's Guide***
- ***Surrounded by Science: Learning Science in Informal Environments*** - Book written for practitioners that is based on the research from ***Learning Science in Informal Environments: People, Places, and Pursuits***
- ***Learning Objectives Builder*** from Arizona State University
- ***Learning Objectives Maker*** from easygenerator.com
- ***Developing Student Learning Outcome Statements*** from Georgia Tech

Reflect

- How do learning outcomes, learning objectives, and assessments support student learning? Why is it important to plan them first?
- What different types of learning could result from a community science program?
- What are learning outcomes and learning objectives? How might you develop them?
- What are summative and formative assessments? What are some examples of each?
- Have you begun developing learning outcomes and summative assessments for your unit? What are they?
- If this is your first time developing learning outcomes, is there a partner with expertise in this area with whom you could collaborate to discuss outcomes and assessments?

Setting Up a Unit Guide

Steps to Planning an Education Program

1. Choose Your Audience
2. Adapt Your Research Question
3. Decide on Logistics
4. Plan Learning Goals & Assessments
5. Set Up the Unit Guide
6. Develop Lesson Guides

A unit guide provides teachers and educators with a big picture introduction to your community science educational program.

Unit guides help teachers and educators easily see how each individual session works toward the goals of the entire program. In our unit guides, we like to include an introduction to our organization and our approach to learning. We also include background information on the MPA and an overview of the entire educational program, including learning outcomes, assessments, logistics (such as what to expect with research teams, field notebooks, and technology), and a description of the learning sequence.

There's no specific defined format that a unit guide has to follow, but we'll provide you with an example of what we like to include. By organizing this information in an easy-to-follow way, you'll provide teachers and educators with the tools they need to begin teaching your program to students.

What You Will Do

As you read through this guide, you will learn about the components of a unit guide and see examples of the components to prepare you to create a unit guide for your MPA education program.

To see what this looks like in practice, check out the ***Teacher Guide*** for Crystal Cove Conservancy's MPA Exploration program.

By the end of this guide, you will be able to...

- Reflect on how a unit guide supports educator success and student learning.
- Describe what should be included in a unit guide.
- Begin setting up a unit guide for teachers or other educators.

Developing the First Page of Your Unit Guide

The first page (or two) of your unit guide gives teachers a high-level overview of the entire program, so that they can quickly see at a glance how it aligns with their classroom goals.

Topic

The topic is a one or two word description of the scientific topic for the entire unit. In the case of our MPA Exploration, the topic is marine ecosystems.

Grade or Age Level

At the beginning of the unit, we make sure to mention the expected age of the participating students. If you are working with informal groups, you can use “Age Level” instead.

Unit Length

This is the number of sessions included in the unit.

Unit Overview

The unit overview provides a big picture summary of what students will do over the course of the unit. It briefly references the ecological issue that is explored and how the sessions that are part of the unit allow students to explore the MPA. It is usually 2-3 sentences.

Essential Questions

The essential questions are connected to the big idea concepts at your local MPA that students will explore. They will use testable monitoring questions to guide the collection and analysis of data in order to to answer these essential questions.

Examples of essential questions include:

- How can we protect the Crystal Cove State Marine Conservation Area?
- How is the Crystal Cove State Marine Conservation Area changing over time?

Summary of NGSS Links

The Next Generation Science Standards describe what students need to know or be able to do regarding science content at different grade levels. On the first page of your unit guide, it is helpful to provide educators with links to appropriate standards so they can see at a glance which standards the overall program addresses.

Make sure to list Performance Expectations, Science & Engineering Practices, & Cross-Cutting Concepts that have a close alignment with the unit. You may choose to list general standard categories (e.g., designing and using models) or a specific standard if there is a very close alignment between a specific standard and the unit.

Welcome to the Program

This section provides a brief introduction to the program, the partners who are integral to its success, and the local Marine Protected Area that is the focus of the program. You might also want to include contact information for any staff members that educators might need to contact.

Developing the Rest of Your Unit Guide

The rest of the unit guide gives teachers a more in-depth introduction to your organization and the program. It should outline who you are, what students will do, and any necessary information that the teacher needs to know in order to prepare for the program.

You can break this into any number of different sections. We recommend including at least the following information.

Information on Your Organization

This section introduces the educator to any information about your organization: who you are, where you work, and why you do what you do. In this section, we also include information on our approach to learning and our commitment to equity and accessibility.

Background Information

This section allows you to describe everything that a teacher will need to know in order to take part in your program. This should include the details of your MPA, the cultural history of the area, and the ecological problem that is at the heart of your monitoring project. You may decide to include a general history of the MPA system in California, a detailed history of your local MPA and the Tribal Nations that have lived there, the stakeholders who were involved in there, the creation of your MPA, and any challenges that were encountered by those involved in the process. You may want to highlight any important issues relating to the complex interactions that come into play when science, community interests, and policy intersect.

We also use this section to provide an overview of the community science project that students will take part in, along with the research questions that they'll answer.

Learning Outcomes and Summative Assessments

The learning outcomes describe what students will be able to know, think, or do after participating in the entire program, along with how you'll measure whether or not students have successfully achieved those outcomes. They often align with the Six Strands of Informal Science Learning.

We like to list the objectives and assessments in a table to make it easier for educators to see the connection between the two. You can see some examples of learning outcomes and summative assessments for a unit below.

By the end of this module, students will be able to...	*You can assess this using...*
1. ***Express*** interest and excitement about taking part in community science research.	Pre- and post-program surveys
2. ***Understand*** how MPA regulations help to protect coastal marine ecosystems.	Observations of student discussions and science journals
3. ***Use*** their model and data visualizations as evidence to support a claim about [how MPA regulations and changes to the environment may affect fish populations in a coastal marine ecosystem].	Research team final products or presentations, graded with a rubric
4. ***Reflect*** on how science knowledge is generated and how that knowledge plays a role in [protecting coastal ecosystems].	Student reflections at the end of the program
5. ***Participate*** productively in scientific practices and the discourse of science, such as constructing a visual model of a marine ecosystem, following protocols to collect data, and constructing a data visualization.	Observations of student discussions and products throughout the program
6. ***Express*** an increased sense that they are able to contribute to the generation of scientific knowledge or protecting the environment.	Pre- and post-program surveys

Content Standard Alignment

Although you listed Next Generation Science Standards briefly at the beginning of the unit guide, this section allows you to include more information on the standards that align with your program. Along with Next Generation Science Standards, you might also list important Common Core or Computer Science Standards here as well.

Overview of the Learning Sequence

The learning guide should also give teachers an overview of the entire learning sequence that students will take part in. We use a table to display a short summary of each session in the program, along with the duration of each session. This allows educators to see at a glance how the sessions build on each other and the time commitment that is necessary to implement the entire program.

Below is a portion of a session overview table from our MPA Exploration.

Sessio	*Overview*	*Session Length*
1 Asking Questions	Students explore the local MPA, generate questions about its ecosystem, and reflect on how they might help protect it. They are also introduced to the community science research project that they'll take part in.	45-60 minutes
2 Building a Model	Students work in research teams to develop a model of the ecosystem.	90-120 minutes
3 Background Research	After identifying any questions about their model, students take part in background investigations to learn more.	90-120 minutes
4 Collecting Data	Research teams visit the MPA to collect data for their research project.	Field trip to local MPA
5 Analyzing Data	Research teams create visualizations to look for patterns in their data, and then use those visualizations as evidence to support a claim about their research question.	45-60 minutes
6 Sharing Our Findings	Research teams design a presentation to share their findings with community members or other stakeholders.	75-90 minutes

Other Logistical Information

In this section, you can describe other information that would be helpful for teachers to know. This could include:

- How learning sessions are structured
- Student research teams
- Field notebooks
- Technological platforms
- Tips on assessments, including any formalized assessments that you want students to take part in
- Any other tips for teaching the program!

Putting This Into Practice

Now that you have learned about all of the components of a unit guide, it is time to put it into practice by creating a unit guide for your MPA program. You can use ***this template*** and ***this example of a unit guide*** to help you through the process.

Reflect

- How does a unit guide support educator success and student learning?
- What is usually included in a learning guide?
- Do you have all of the information needed to create a unit guide for teachers or other educators? If not, what information do you need to gather?

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Setting Up a Lesson Guide

Steps to Planning an Education Program

Lesson guides are used by educators to help them teach each individual lesson during a unit.

When we design lesson guides, we try to intentionally design them in a way that incorporates the key components of an effective lesson. This ensures that the educator who is teaching the lesson understands the intent of the lesson and the steps to implementing it. This is particularly helpful when the person implementing the lesson did not design the lesson. It also ensures that multiple people can implement the same lesson and the learners' experience won't dramatically vary because of who is implementing the lesson.

Like a unit guide, there is no standardized format that all lesson guides must follow. As you go through this guide, you'll learn more about the format that has worked well for us, as well as some other considerations that you may want to keep in mind as you prepare to develop your

What You Will Do

As you read through this guide, you will learn about the components of a lesson guide and see examples of the components to prepare you to create a lesson guide for each of the sessions for your program.

After you review this guide, you'll be ready to create lesson guides for your own MPA community science program, which you'll move on to do next!

By the end of this guide, you will be able to...

- Reflect on how lesson guides support educator success and student learning.
- Describe what should be included in a lesson guide.
- Reflect on how the learning cycle can help design lessons that are structured to support student learning.

Structure of a Lesson Guide

For each lesson in the unit, we provide a lesson guide to assist the teacher with implementing it in their classroom. The lesson guide contains the following sections, which are described in more detail below.

At the beginning of each lesson guide, just like in our unit guide, we like to include some basic information as a quick snapshot. This includes:

- Session Focus
- Grade or Age Level
- Lesson Location
- Lesson Length
- Big Idea
- Driving Questions
- Session Overview

Later in the lesson guide, we include the following information:

- Learning Objectives & Assessments
- Content Standards Links
- How This Session Supports Diverse Learners
- Materials List
- Tips for Advance Preparation
- Background Information Resources
- Learning Sequence, which includes directions for Launch, Explore, Share, and Reflect

Developing Your First Lesson Guide

The first page (or two) of your lesson guide gives teachers a quick snapshot of what to expect with this particular lesson.

Session Focus

At the start of each lesson guide, we like to include a short summary of what students will be doing or learning in the session. This gives educators a quick, at-a-glance overview of what to expect from the session.

We tend to use one or two words here. This could either be what students are doing, such as designing a model, or what they are learning about, such as energy flow through an ecosystem.

Some example session focuses include:

- Asking Questions
- Designing a Model
- Energy Flow
- Collecting Data
- Science Communication

Grade or Age Level

At the start of each lesson guide, we also make sure to mention the expected age of the participating students. If you are working with informal groups, you can use “Age Level” instead.

Lesson Location

If your MPA community science program will potentially take place in different types of locations, such as in the classroom or at the beach, you may want to specify where each session is intended to be located.

Lesson Length

This is the expected amount of time that the lesson will take. Sometimes, lessons may be split up over multiple class meetings.

Big Idea

This is a 1-2 sentence summary encapsulating the big idea that students will learn by the end of the lesson. It might involve conceptual knowledge, such as the ecosystem in a local MPA, or it could involve the scientific process, such as why and how scientists use models.

Some example big ideas are:

- Students build knowledge about California's Marine Protected Area (MPA) network and the creation of the Marine Life Protection Act. They will learn about media literacy while doing research into MPAs and generate questions about what they want to learn more about.
- Students zoom into Crystal Cove's State Marine Conservation area and are introduced to the idea that we are trying to monitor its health. By creating a computer model, students will describe the components and processes that contribute to the health of the State Marine Conservation area.

Driving Questions

A driving question is posed to students in order to drive or direct their investigation during a lesson. Students can expect to answer these questions by the end of the session.
We usually include 2-3 driving questions at the start of each lesson. Some examples include:

- What do we need to know about California's MPA system?
- How can we determine if an information source is reliable?
- What can we monitor to see if the Crystal Cove SMCA ecosystem is changing over time?
- What do we need to know to collect data?

Session Overview

The session overview provides a short summary of what the students will do during the session. It connects the description of what they will do with the section of the lesson and includes the duration and format of each component.

We like to share this information with educators in a table to make it easier for them to see at a glance what the students will do. Below is an example of a session overview from the Designing a Model session.

Example Session Overview

Section	Description	Length	Format
Launch	Students watch a video that introduces them to the idea of creating a model.	5 minutes	Whole class
Explore	Research teams generate a list of components and processes that might affect fish populations in the Crystal Cove SMCA. Students then work independently to create a draft model in their field notebook.	20 minutes	Research teams & individual
	Research teams then come back together to create a collaborative model using Padlet, SageModeler, or another online platform of the teacher's choice.	30-45 minutes	Research teams
	Optionally, research teams can also use their models to make predictions about how changes to the ecosystem will affect the fish population.	15-20 minutes	Research teams
	Finally, research teams identify what questions they still have about their model.	5 minutes	Research teams
Share	If there is time, students share their models with the whole class.	15 minutes	Whole class
Reflect	Students reflect on what they've learned from their model and what their next steps might be.	5-10 minutes	Individual

Designing the Rest of the Lesson Guide

After the high-level overview of the lesson, we include additional information to help teachers deliver it.

Learning Objectives and Assessments

After sharing information about how to support diverse learners, the next items to include are the learning objectives and formative assessments for that lesson.

Learning objectives describe what students will be able to know, think, or do after participating in a lesson. They should be specific and measurable and describe an action that students will be able to demonstrate that indicates their knowledge, skills, attitudes, and behaviors so that the educator can assess whether students have achieved the objective.

We like to list the objectives and assessments in a table to make it easier for educators to see the connection between the two. Below is an example of the learning objectives and assessments for the Designing a Model session.

By the end of this module, students will be able to...	*You can assess this using...*
1. *Generate* a list of biotic components, abiotic components, and processes that affect fish populations in the Crystal Cove SMCA.	Field notebook entry or shared Google Doc
2. *Create* a model that shows how biotic components, abiotic components, and processes might affect the fish populations in the Crystal Cove SMCA.	Research team models
3. *Use* computational thinking to predict environment will impact the fish populations in the Crystal Cove SMCA.	Field notebook entry or shared Google Doc
4. *Reflect* on why scientists use models to make predictions about real-world systems.	Whole class discussion

Content Standards Links

After the learning objectives, we list connections to Next Generation Science Standards and other content standards. This allows educators to see at a glance which standards the lesson addresses.

As you list Performance Expectations, Science & Engineering Practices, or Cross-Cutting Concepts, make sure to only include those that have a close alignment with the lesson itself.

How This Session Supports Diverse Learners

Because students bring their own unique experiences and knowledge to each lesson, each learner may need slightly different support to help them succeed. We like to provide teachers with suggestions for how to support students based on the details of each lesson.

In this section, we include strategies that we have found to be helpful, including providing all students with a common experience, providing screencasts when students are introduced to new online platforms, providing videos of how to use equipment, and giving students choices in assignments.

We'll mention some relevant strategies to support diverse learners in each planning document, and you can decide what to include in your lesson guide.

Materials List

This is a bulleted list of what educators and students will need to participate in the lesson. It includes both physical materials, like field notebooks or data collection equipment, as well as virtual materials, such as links to a slideshow or a model template.

Tips for Advance Preparation

This is a bulleted list of what the educator needs to do before the lesson starts. It includes activities such as downloading slideshows, updating slides in a slideshow if necessary, making decisions about a technology platform, and deciding if you need to split the lesson into multiple sessions.

Background Information Resources

This is a list of resources that provide background information on the topic of the lesson to help the educator feel more comfortable presenting the information to students and prepare them for questions they may receive from students. These resources can also be used so that teachers and/or students can continue to explore the topic in more depth.

Learning Sequence

Carefully designing a learning sequence ensures that lessons will support the needs of students as they progress through the lesson and successfully build knowledge based on their prior knowledge and experiences. The learning sequence section of a lesson guide provides the teacher with the details of how the lesson is structured and what they will do to implement the lesson.

Each session within the MPA Exploration is broken down into four sections. These sections align with the five elements of the BSCS 5E Learning Cycle Instructional Model (although we use slightly different names).

- **Launch (or Engage):** At the start of every session, students are introduced to the day's driving question and share their initial ideas about the topic.
- **Explore:** Next, students take part in short investigations related to the module's driving question. These investigations are designed to be flexible, and can take place in the field or during scheduled class time at school.
- **Share (or Explain & Expand):** Students come back together to share their observations and discuss their ideas with their peers. These discussions may take place in student research teams or as a whole class. We have found it helpful to include slides with suggested science discussion norms, sentence starters, and suggested questions to get teachers started, which they can adapt for their class.
- **Reflect (or Evaluate):** At the end of each session, students respond to questions and reflect on what they've learned so far in their field notebook.

Putting This Into Practice

Now that you have learned about all of the components of a lesson guide, it is time to put it into practice by creating lesson guides for all of the sessions of your MPA program. You can use the templates linked below and ***this example of a lesson guide*** to help you through the process.

Resources

- ***Information about BSCS 5E Instructional Model***
- ***Explanation of the 5E Instructional Model***
- ***Session 1: Asking Questions Lesson Guide Template***
- ***Session 2: Building a Model Lesson Guide Template***
- ***Session 3: Background Research & Media Literacy Lesson Guide Template***
- ***Session 4: Collecting Data Lesson Guide Template***
- ***Session 5: Analyzing Data Lesson Guide Template***
- ***Session 6: Sharing Your Findings Lesson Guide Template***

Reflect

- Do you feel confident that you have enough information and experience to write all of the sections in a lesson guide? If not, where can you find more information to help you complete those sections? Is there another educator or a partner with expertise who could assist you?
- Will you be able to use the 5E lesson structure for all of your lessons? Do you need to modify any of your plans in order to align with the 5E lesson structure?

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Session 1: Asking Questions

Education Program Structure

At its heart, science is about curiosity, and curious scientists ask questions.

Scientists ask questions about their observations of plants, animals, and natural phenomena. They ask questions about scientific investigations, and how best to solve environmental problems that affect communities all over the globe. If we want students to experience an authentic scientific process, they need to be able to ask questions about phenomena that they observe and be able to pose questions to their peers.

In Session 1, students have the opportunity to explore the ecosystem for the community science program and begin to ask questions about phenomena they observe there. They think about how that ecosystem might change over time and what might cause those changes, and they begin to ask questions about how to protect it. These questions that they create help them to start to direct their investigation and get them personally invested in the process.

What Students Will Do

During ***Session 1: Asking Questions***, students explore the place where the community science project is located and begin asking questions about how best to protect it.

At the start of the session, students are introduced to the place that they will help protect. They are divided into their research teams, set up their field notebooks, and establish norms for communication and discussion. After, they are given a chance to explore the place where the community science project is located, either in person or virtually, and begin identifying their questions about how best to protect it.

To see what this looks like in practice, check out the ***Welcome to the Crystal Cove SMCA! session*** in Crystal Cove Conservancy's MPA Exploration program.

How This Session Supports Diverse Learners

As you launch your MPA community science program, this first session offers the opportunity to make sure that all students have a similar initial experience that they can draw from as they begin exploring your local MPA. Having a shared experience or shared exposure to a phenomenon helps support diverse science learners because it ensures that everyone has an experience in common that they can discuss and build on.

Session 1 also offers an opportunity to connect the place you're studying with students' funds of knowledge. Every learner has had their own personal experiences with nature. As students explore the place that they've been asked to help protect, they may make connections with their own past experiences in the outdoors or cultural knowledge of similar plants and animals. It can be helpful to build in time for students to share these stories and personal connections, either with the whole group or in a personal reflection, so that they have an opportunity to personalize their connection to the space.

As you're designing for diverse learners, it is important to keep their prior experiences in similar spaces in mind. If you're bringing a group on a field trip, educational research has suggested that giving students clear directions on what to expect and what they'll do during the excursion increases their learning. If your audience assessment suggests that some students may not have visited the local MPA before, you'll want to clearly describe the experience in advance, think about ways to make them feel safe during the visit, and build in time for them to explore and appreciate the space.

Finally, you can also use this session to introduce learners to the local Tribal Nation in your area. This gives learners from Indigenous backgrounds a chance to see Tribal history and cultural background included in a respectful way. We highly encourage building a connection with your local Indigenous community and letting them decide the best way to integrate their history, perspectives, and traditional knowledge into the program. We've included more of a discussion of how you might approach this later on in this guide.

Designing Learning Outcomes

As students begin exploring the place where your community science project is located, they begin to develop an understanding of its rich history and natural resources, as well as considering why it might be deserving of protection.

Some of the learning outcomes in this first session may be more factually-based. You may want students to make observations, to identify different plants or animals within the ecosystem, or to describe its cultural history and connection with a local Tribal Nation. You might also want them to summarize the community science research project that they'll be taking part in.

This session is also an opportunity for students to generate their own questions that they have about the place or the people that have lived there. They might reflect on past experiences that they've had in similar locations, or share any cultural or family knowledge related to marine ecosystems. They could also begin sharing their initial ideas about ways that they can help protect it.

Finally, we like to use this first session to ask learners to start reflecting on the process of science. As you introduce discussion norms, establish field notebooks, or divide students into research teams, you can ask them to reflect on how these different aspects play a role in the practice of science.

Example Learning Outcomes

By the end of this module, students will be able to...	*You can assess this using...*
1. ***Describe*** [the ecosystem and cultural history] in their local MPA.	Student discussions
2. ***Summarize*** The community science research project that they'll take part in.	Student discussions
3. ***Generate*** a list of questions about [the local MPA].	Student discussions; Field notebook notes
4. ***Share*** their initial ideas on ways to protect the local MPA.	Student discussions; Field notebook reflections
5. ***Reflect*** on whether their local MPA is a place worth protecting.	Student discussions; Field notebook reflections
6. ***Reflect*** on how field notebooks, research teams, and discussion norms play a role in the practice of science.	Field notebook reflections

Possible Links to School Standards

As you're designing your learning objectives, it can be helpful to connect directly to school content standards. For this first lesson, there aren't many NGSS Performance Expectations that involve the scientific practice of Asking Questions, so it may be challenging to make direct links.

Instead, we recommend linking your learning outcomes to the NGSS Science & Engineering Practice centered on Asking Questions & Defining Problems. You can also think about linking to Cross-Cutting Concepts such as Systems & System Models by having students identify components of the ecosystem, which they can later use to build their model, or Cause & Effect by having them think about how human activity has caused the place to change over time.

We've listed a few possible links that you might consider below.

Next Generation Science Standards

Science & Engineering Practices

- Asking Questions & Defining Problems
- Obtaining, Communicating, & Evaluating Information

Cross-Cutting Concepts

- Systems & System Models
- Cause & Effect

How to Plan the Learning Sequence

As you start to develop a learning sequence for ***Session 1: Asking Questions***, you will need to make several major decisions:

- Develop driving questions
- Identify what students need to know about Marine Protected Areas, their local MPA, and the community science research project that they'll take part in
- Decide how to introduce program logistics, such as breaking students into their research teams and setting up field notebooks
- Choose how to help students ask questions and explore the local MPA
- Consider how to integrate connections to the local Tribal Nation
- Decide how to introduce the research project

Each component will be described below with tips and examples to help you create your own learning sequence.

Develop Driving Questions

As you begin to develop your session, you'll want to select driving questions to direct the investigation for students. These driving questions give students an idea of what they'll do and learn during the session.

Some example driving questions include:

- What do we notice about our local Marine Protected Area?
- Why do we care about protecting it?

Identify What Students Need to Know

Before you start considering how you want students to explore your local MPA, it's helpful to consider what you want them to know at the end of this first session. This will help you decide what information to include (and may also inform your learning outcomes).

Although it can be tempting to make a long list, we think it's important to narrow down your list and focus on a few key ideas. This could include information on the area's cultural or natural history, how it has changed over time, why people care about protecting it, and any key ideas that students may need to know about the community science research project.

An important component of this is also the "why" -- why do we need to protect the local MPA? Whether or not you expect that your participants have direct experiences in nature, taking time to share and reflect on our reasons for investing time and resources in protecting a place gives students a reason to participate in and care about the rest of the project. Ways to set up these reflections include sharing perspectives of different local stakeholders, exploring the biodiversity of the marine ecosystem and discussing why that biodiversity is important, or giving students a chance to experience the place firsthand.

As you get started, make a list of what you want students to know or understand by the end of this first session.

- What is the cultural history of the place? What Tribal Nation(s) is the original steward of the land and waters? Who else has lived or worked there?
- What is the ecosystem like? What are some major features or key species?
- What is most noticeable about the place? Are there any major or unique features that students are likely to remark on or ask questions about?
- How has the place changed over time? What are the major threats that it faces?
- Why do people care about protecting it today? Who are the key stakeholders?
- What else do students need to know about the place?

As you generate this list, you may realize that there is more information than you can cover in one meeting. That is okay! We commonly find that we have to devote more time to Session 1 or split it into multiple short sessions. Giving students time to ask questions and explore the place will help them become invested in protecting it.

Decide How to Introduce Program Logistics

In Session 1, we've found it's important to allow time for setting up program logistics. This includes giving directions on how to do things, such as breaking into research teams, setting up field notebooks, and establishing norms for science discussions.

In addition to giving directions, we've found it is also important to take time to reflect on how the program logistics mirror science practice. Professional scientists commonly work in teams, use notebooks to keep track of their thoughts and ideas, and talk to each other in certain ways. Positioning students to think about the reason behind these decisions creates a metacognitive opportunity for them to reflect on how what they're doing aligns with real practicing scientists.

For an example of what this looks like in practice, check out ***the slideshow for Session 1*** in Crystal Cove Conservancy's MPA Exploration program.

Choose How to Help Students Ask Questions & Explore the Local MPA

During this first session, you'll also want to give students a chance to explore the place that is the focus of your community science project. Ideally, it is always most impactful to bring students to this place in person, but there are other strategies that you could use if that is not possible.

Some options include:

- Taking a field trip to visit the local MPA
- Virtual exploration through a platform like Thinglink
- Student-directed investigations and presentations to answer their own questions about the area (perhaps using media literacy strategies, which we discuss more in ***Session 3: Background Research & Media Literacy***)

If you can't visit the location in person, we've found that Thinglink is an incredibly effective tool to visit a place virtually. As well as letting students explore the space, it also allows you to draw their attention to certain characteristics, which ensures that you can guide them towards the key ideas that you want them to know. Although the full version of Thinglink is $750 for nonprofits, there are educator versions that are more affordable.

You can check out examples of how we've used Thinglink to explore different spaces during ***Session 1: Asking Questions*** in different ways in our ***MPA community science program*** and our ***restoration ecology community science program*** for elementary students.

Once you decide on how to explore the space, you'll also want to think about how you can support students in making observations and identifying the things they wonder. Different strategies that you might use include:

- Giving students time to explore and record their observations or questions in a field notebook
- Sharing observations and wonderings during a discussion, either as a whole group or with a partner

Consider How to Integrate Connections to the Local Tribal Nation

As students start exploring the place that they'll help protect, we think it's also important to highlight the Tribal Nation and people who are the traditional stewards of those lands and waters. We've begun working with Acjachemen and Tongva Tribal Members to ensure that their perspectives are incorporated into our MPA Exploration program.

It is important to develop these ideas in partnership with the Tribe or with Indigenous organizations. Tribal Elders may choose to share what they'd want students to know or realize about the area, its history, their connection to it, and their relationship with it today.

If you are reaching out to a Tribal Nation for the first time, be prepared to pay them a stipend for their time and expertise, rather than asking for them to volunteer to contribute.

Decide How to Introduce the Research Project

In Session 1, we also introduce students to what they'll be doing throughout the entire community science program. We might have them visit the research site and make observations, watch a video from any partner scientists, or introduce the main topic and ask them to generate ideas about questions they would ask or strategies they might use to address the problem.

As you're planning this session, decide how you might introduce the community science research project to students. There will be time later to get into logistics (such as how they'll collect data).

- What do students need to know about the community science research project?
- What is the main question that they'll help to answer?
- Who are the key people involved?
- What are they studying or monitoring?

Learning Sequence

Session 1: Asking Questions may take place during a field excursion to your local MPA, or could take place at a school or other site. Depending on how much you want to cover, you may consider breaking it into two or more meetings.

Launch

Getting Started (10-20 minutes)

1. Welcome students to the program! Briefly welcome them to the local MPA and introduce the big problem that they'll help solve.

2. Introduce the idea of community science: students will step into the shoes of scientists to help investigate a research question related to the local MPA. They'll be tasked with asking questions, developing and refining a model, collecting data, analyzing that data, and then sharing their findings.

3. Suggest to students that as they take part in the program, they'll be using the same strategies and tools that professional scientists use. Go over the logistics of how students will work during the program, making sure to frame it in terms of science practice:

   a. Ask students to reflect on why scientists might work in teams, rather than working independently. Afterwards, give them directions on how to break into their research teams.

   b. Invite students to share ideas on how scientists could keep track of their thoughts and ideas as they investigate a topic. Introduce any information on how students will use field notebooks during the program.

   c. Finally, ask students to share their ideas about how scientists communicate with each other. Elevate ideas related to asking questions, supporting claims with evidence, and listening closely to each other. Depending on their age and the time available, you can invite students to come up with their own guidelines for science communication or share a list of science communication guidelines with them.

Explore

Exploring and Asking Questions (30+ minutes)

Give students time to explore the place where your community science project is based. Depending on what method you've chosen, this could take the form of a virtual exploration, a hike, a boat trip, or independent research into different questions that they have. It may be more or less structured, depending on the age group that you are working with.

As students explore, draw their attention to different features. Encourage them to share their observations, thoughts, and questions out loud.

As you finalize your plan for exploration, make sure to include specific instructions in this section on that you want your educators or leaders to do.

Share

Sharing Our Questions (10 minutes)

1. Gather the group back together and give them a chance to share what they've noticed.

- What did you notice? What stood out to you?
- What questions do you have? What do you owner about?
- Do you think it's important to protect a place like this? Why or why not? What could we do to protect it?

Reflect

Reflecting on the Session (5-10 minutes)

1. Introduce the idea of reflection to students. Invite them to share why they think reflecting on our process is an important part of science.

2. Tell students that at the end of each session, you'll give them time to use their field notebooks to reflect on their experiences. They'll be provided with a few questions that they can respond to.

3. Share the reflection questions for the day, and ask students to spend a few minutes reflecting in their field notebooks.

Resources

- ***Science and Engineering Practices in the NGSS: Asking Questions and Defining Problems***
- ***Using Phenomena in NGSS-Designed Lessons and Units***

Reflect

- How does this initial session support student learning?
- How will you support students as they start to form a learning community? How will you break them into research teams? How will you introduce field notebooks?
- What is important for your students to know or understand by the end of this session?
- How will you have students explore your local MPA? How will you support them in asking questions?
- How might you integrate connections to your local Tribal Nation?

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Session 2: Modeling

Education Program Structure

Developing models is an important part of science practice.

Creating a model of a system allows students to formalize their initial ideas about how that system works. They can use their models to identify their questions or areas of uncertainty about the ecosystem, and can also use them to make predictions or hypotheses about interactions. Later, after collecting data, they can test their ideas by analyzing that data to see if it supports the relationships in their model.

As you explore how to design this session, we encourage you to use a conceptual model, which shows the relationship between different factors within the marine ecosystem, or a simple mathematical model, which defines the relationships between different factors using conditional statements. You can also layer in other ideas related to your learning outcomes, such as having students map the transfer of energy or matter through the ecosystem.

What Students Will Do

During ***Session 2: Modeling***, students work in small teams to create a model that shows their initial ideas about interactions within the marine ecosystem under study.

First, student research teams brainstorm different components and processes that might affect the main question that they are studying. After identifying the most important factors from their list, they create a model that shows how these different factors are related to and influence each other. Finally, they identify any questions that they have about their model. Those questions are later used to guide their background research in Session 3.

To see what this looks like in practice, check out ***the Modeling session*** in Crystal Cove Conservancy's MPA Exploration

How This Session Supports Diverse Learners

The process of creating an explanatory model is well-adapted to support diverse learners. As students collaboratively build a model, they have an opportunity to share their initial ideas and negotiate their understanding of how a system works. Modeling can also help support emerging bilingual students by giving them a chance to first explain their ideas graphically, and then layer on scientific vocabulary.

As you design this session, we highly encourage you to consider using video demonstrations or screencasts as scaffolds to support student engagement, especially if you're having students create their model using SageModeler, Padlet, or another online platform that may be new to them. Video demonstrations allow students to move through the session at their own pace and refer back if they have questions, offering support to students who may not have engaged in modeling work or used these specific technologies before.

Designing Learning Outcomes

When students build a model, they begin to explore and document their ideas about the marine ecosystem in the Marine Protected Area that they're studying. Building models also offers a prime opportunity for students to reflect on the practice of science, specifically considering why scientists use models to make predictions about real-world systems.

A modeling lesson can be designed to support specific learning outcomes. Students could think about cause and effect between different factors within the ecosystem -- essentially, how one factor (like salinity) causes another factor (such as the fish population) to increase or decrease. The lesson could also be designed to focus on the movement of energy and matter, or you might ask students to sort their factors by classifying naturally-occurring parts of the ecosystem and human-caused changes.

Choosing a specific focus for your model may help you to link to specific Next Generation Science Standards Performance Expectations, which in turn will help to align your program with learning needs for different grade levels. Below, we've suggested some different formats for learning outcomes, depending on what you want your modeling activity to focus on.

Example Learning Outcomes

By the end of this module, students will be able to...	*You can assess this using...*
1. ***Describe*** [the ecosystem and cultural history] in their local MPA.	Student discussions
2. ***Summarize*** The community science research project that they'll take part in.	Student discussions
3. ***Generate*** a list of questions about [the local MPA].	Student discussions; Field notebook notes
4. ***Share*** their initial ideas on ways to protect the local MPA.	Student discussions; Field notebook reflections
5. ***Reflect*** on whether their local MPA is a place worth protecting.	Student discussions; Field notebook reflections
6. ***Reflect*** on how field notebooks, research teams, and discussion norms play a role in the practice of science.	Field notebook reflections

Possible Links to School Standards

As you're designing your learning objectives, it can be helpful to connect directly to school content standards. For this first lesson, there aren't many NGSS Performance Expectations that involve the scientific practice of Asking Questions, so it may be challenging to make direct links.

Instead, we recommend linking your learning outcomes to the NGSS Science & Engineering Practice centered on Asking Questions & Defining Problems. You can also think about linking to Cross-Cutting Concepts such as Systems & System Models by having students identify components of the ecosystem, which they can later use to build their model, or Cause & Effect by having them think about how human activity has caused the place to change over time.

We've listed a few possible links that you might consider below.

Next Generation Science Standards

Performance Expectations

- Fifth Grade
    - ***5-PS3-1 Energy:*** Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.
    - ***5-LS2-1 Ecosystems: Interactions, Energy, and Dynamics:*** Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.
- Middle School
    - ***MS-LS2-3 Ecosystems: Interactions, Energy, and Dynamics:*** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
- High School
    - ***HS-LS2-5 Ecosystems: Interactions, Energy, and Dynamics:*** Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.
    - ***HS-ESS2-6 Earth's Systems:*** Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

Science & Engineering Practices

- Developing and Using Models

Cross-Cutting Concepts

- Systems & System Models

How to Plan the Learning Sequence

As you start to develop a learning sequence for ***Session 2: Modeling***, you will need to make several major decisions:

- Develop driving questions
- Decide how to frame your model
- Develop a modeling question
- Decide how to support students in brainstorming, sorting, and prioritizing factors
- Choose a modeling platform
- Decide how to support students in building their model

Each component will be described below with tips and examples to help you create your own learning sequence.

Develop Driving Questions

As you begin to develop your session, you'll want to select driving questions to direct the investigation for students. These driving questions give students an idea of what they'll do and learn during the session.

Some example driving questions include:

- How can we create a model of the marine ecosystem that we want to study?
- How will different factors affect [the population that we're studying]?
- What questions do we have about our model?

Decide How to Frame Your Model

Next, you'll need to decide how you want to frame your model for student learning outcomes. This will be closely linked with your learning objectives.

Some possible frames include:

- Movement of energy through an ecosystem
- Movement of carbon or another kind of matter through an ecosystem
- Cause and effect
- Human impact on ecosystems

Develop a Modeling Question

Once you've thought about how to frame your model, the next step is to develop a modeling question that will guide students through the activity.

The best modeling questions are connected to a specific phenomenon that is situated in a specific location. If a question is too general, such as "How does energy move through a marine ecosystem?", then the exercise can devolve into drawing a diagram of a process, rather than thinking specifically about complex relationships inside the system.

To start developing a modeling question, try to answer the following questions:

- What specifically are you studying? This is likely mentioned in your research question.
- Where are you studying it?
- What learning frame do you want to use?

Example modeling questions include:

- How do biotic components, abiotic components, and processes affect the biodiversity of fish in the Crystal Cove SMCA?
- How do naturally-occurring and anthropogenic factors affect the growth of giant kelp in the Crystal Cove SMCA?
- How does human activity impact the number of owl limpets in the Crystal Cove SMCA?
- How does the movement of energy affect the presence of kelp in the Crystal Cove SMCA?

Decide How to Support Students in Brainstorming, Sorting, and Prioritizing Factors

Once you've developed a modeling question, the next step is to decide how you want students to brainstorm and sort the factors to include in their model.

To drive brainstorming, we provide students with an adapted version of our modeling question, switching "How" to "What." For example, we might adapt the first modeling question to read, "What biotic components, abiotic components, and processes affect the biodiversity of fish in the Crystal Cove SMCA?"

Giving students specific categories to sort their factors gives them a framework for their brainstorming. We commonly use biotic factors, abiotic factors, and processes in our modeling sessions, but other options work too. You might choose to sort environmental factors versus human-created factors, or something entirely different. Depending on your model, you may also want to encourage students to think about categories instead of getting too specific. For instance, it may be simpler to use "predators" as a blanket term, instead of brainstorming every possible species.

Once students brainstorm their list of factors, it is also helpful to give them time to prioritize their list. Often, we've found that students will focus on exciting ideas (like great white sharks) that might not have a huge effect on the model itself. We usually ask students to choose the 5-10 most important factors to include in their model.

Choosing a Modeling Platform

Depending on your needs, you can choose from a variety of different modeling options. These range from simple pen-and-paper representation models to more complex models created on specialized online platforms.

	Pen and Paper	Padlet	SageModeler
Description	Physical model using a posterboard, crayons or markers, and post-it notes	Online collaborative workspace	Online platform designed specifically for modeling and data analysis
Cost	Materials cost	Free for first three boards; requires $10/month subscription for additional boards	Free
Age Group	Elementary Students (also works for middle and high school students)	Middle and High School Students	Upper Elementary, Middle, and High School Students
Pros	Does not require the use of technology or computers. Allows the integration of art. Can take place outdoors or in other locations besides the classroom. Modeling can be done collaboratively with a group of students. Teacher can see thinking in real time.	Modeling can be done collaboratively with multiple students using one online workspace at the same time. Teacher can see thinking in real time. Students can import videos, links, and images within the posts.	Specifically designed to support student modeling. Has a clear way to define computational relationships between components and processes. Can run simulations to see the effects of one component on another. Can import data to test the model and make graphs (which can be used to analyze data later on).
Cons	Requires physical materials. Much more difficult to show links and explain relationships.	More difficult to show links and explain computational relationships. A free account can only create three Padlets (meaning students will need to sign up for their own account). Cannot import data and use it to test the assumptions in the model.	Only one person can manipulate the model at a time (meaning one student will need to manipulate the model and share their screen with others). Teacher can only view the contents when the link is shared, so it is hard to see thinking in real time.

Decide How to Support Students in Building a Model and Identifying Their Questions

Once you decide on a modeling platform, the last step is to decide how to scaffold the activity for students. We've found that it is helpful to go through the process of creating a practice model yourself to see what sorts of ideas students might include and identify if there are any places where they might struggle.

If you are teaching the lesson in person, you will want to plan what directions to give students and how to demonstrate the different tasks. You may also want to think about how to structure the lesson to allow students to share their ideas amongst their collaborative team. One effective strategy for younger learners involves having them draw their own individual model first on a small piece of paper, then come together as a team to create a larger model.

If you are creating materials for classroom teachers to use, you may want to include additional support to help them use the platform. This could include filming screencasts or videos to demonstrate how to use the different platforms.

If you're using an online platform such as Padlet or SageModeler, you'll also want to set up a template for students to start with. Check out our videos for getting started on ***Padlet*** and ***SageModeler***!

If you'd like to see some different examples of what this looks like in practice, check out our slideshows below:

- ***Padlet Lesson Guide*** and ***Slideshow Example***
- ***SageModeler Lesson Guide*** and ***Slideshow Example***

You can also support students in using their models to make predictions about ecosystem change. This is built into the SageModeler platform, but check out the above examples to see how we've incorporated predictions into models built using pen-and-paper or on Padlet.

Finally, you'll also want to decide how to help students identify their questions when they are done drafting their model. If you are using pen-and-paper modeling or Padlet, you can have students add a sticky note in a different color to denote their questions. If you are using SageModeler, you might have them make a list of their questions in their field notebook.

Learning Sequence

Typically, a modeling session takes about 60-90 minutes for students to complete. If you have less time available in a single meeting, you can break it into two sections: the first focused on generating a list of factors, and the second focused on building the model.

Launch

Getting Started (10-20 minutes)

1. Share the driving question for the day, and then introduce students to the idea of using models to show our ideas about interactions within a system.

- What is a model? What are some different kinds of models that you've used before?
- Why might scientists use models?
- How can a model help us think about our research question?

Explore

Generating a List of Factors to Include in Your Model (20 minutes)

1. Divide students into their research teams. Explain that before you begin creating your model, you'll need to think about all of the different factors that might influence the population or ecosystem component that you are studying.

2. Ask students to share a few examples of factors, and demonstrate how to sort them into the categories that you've chosen to use.

3. Give students any additional instructions, and then ask them to spend ten minutes brainstorming all of the factors that might impact the focus of your community science project. For now, tell them that any ideas are good ideas: just put everything they can think of on their list.

4. When time is up, ask students to go back through their list and draw a star next to the 5-7 items that they think will have the biggest impact on the focus of your study. Optionally, at the end of this, you can also ask teams to share their list with the whole class.

- What factors might affect…?
- How can we sort these factors into categories?
- Which 5-7 factors are the most important? Which ones do we want to be certain to include in our model?

Creating a Model (40-60 minutes)

1. Introduce the modeling platform to students. Demonstrate how to add the central factor to a model, and then begin adding any other components and processes. As students connect components and processes, encourage them to add a description of the different relationships.

2. Give student teams time to work on their models independently. As needed, you can circulate around the group to check on them and see how they're doing.

Identifying Questions (10 minutes)

1. Once the student teams have finished creating their models, ask them to go back through and identify 3-5 questions that they have about their model. This could be places where they need clarification, connections or relationships that they're unsure about, or factors within their model that they want to learn more about.

2. Have students record their questions, either by including them on the model itself or by listing them in their field notebook. You'll have a chance to revisit these questions in Session 3.

Share

Sharing Our Questions (10 minutes)

1. Invite student teams to share their models! This could take the form of a gallery walk, where you set the models out and students have a chance to leave feedback, or through short student presentations.

- What was it like to create a model?
- Describe your model. What does it show? How do different factors affect the central part of your model?
- What questions do you still have about your model?
- Why do scientists use models like these? How can they help us to make predictions about an environmental system?

Reflect

Reflecting on the Session (5-10 minutes)

1. At the end of the session, ask students to spend a few minutes reflecting on their experience today in their field notebook or another journal.

- What did you do today? What did you learn?
- What questions do you still have?
- Why do scientists use models? How can they help us to make predictions about an environmental system?

Resources

- ***Models and Modeling: An Introduction*** from ***Ambitious Science Teaching***
- ***Tools for Using Scientific Modeling*** from Tools for Ambitious Science Teaching Website
- ***Science and Engineering Practices in the NGSS: Developing and Using Models*** (Page 6)
- ***What is Meant by Engaging Youth in Scientific Modeling?***

Reflect

- How does modeling support student learning?
- What is it that you want learners to study? How can you create a modeling question focused on this central idea?
- What factors factors are learners likely to think of including in their model? How will you have learners sort the factors in their models and identify what's most important?
- What modeling platform do you want to use? How will you demonstrate how to use it?
- What scaffolds will you give students to support them as they build their model and identify their questions?

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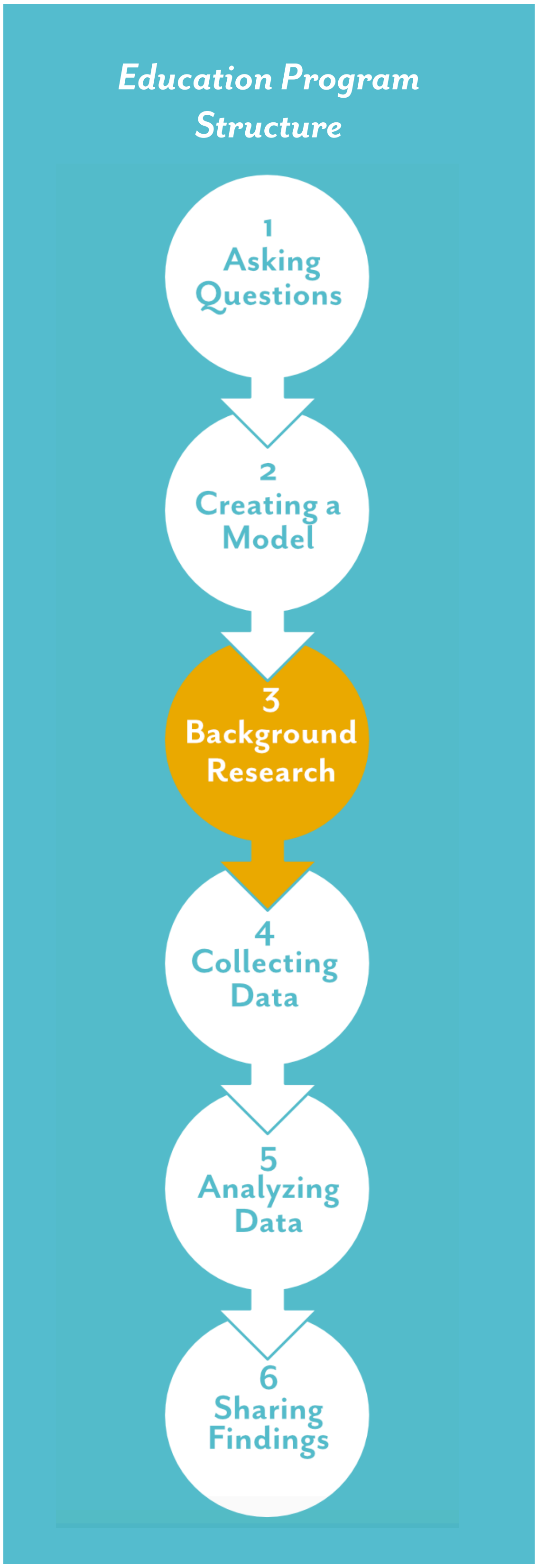
Session 3: Background Research & Media Literacy



Designing models invite students to ask more questions.

When students conduct background research, they're able to clarify questions about their model that they may have wondered about or been unsure of. Students are then able to integrate these new ideas into their models, thus expanding or refining their understanding of the environmental system.

In Session 3, background research can involve hands-on investigations that invite students to explore different aspects of environmental systems. For older students, background research may also take the form of looking up information online, providing a natural link to media literacy. Scaffolding tools like a Summary Table can also help students maintain a record of their activity and idea, which are then easy for them to refer back to when they revise their models.

What Students Will Do

During ***Session 3: Background Research and Media Literacy***, students identify the questions that they have about their model and conduct background investigations to learn more about different parts of the system.

First, students return to the models that they created in ***Session 2: Building a Model*** and identify any questions that they want to answer. Then, based on the questions that students identify, they take part in background investigations or use lateral reading strategies to research the answers online. Finally, they use what they've found to revise their models and, if applicable, create a hypothesis.

To see what this looks like in practice, check out the ***Asking Questions About MPAs*** and ***Diving Deeper sessions*** of Crystal Cove Conservancy's MPA Exploration program.

How This Session Supports Diverse Learners

During Session 3, students have a chance to identify their questions about their model and then find the answers. The design of this session acknowledges that students have had different experiences in the past, and gives the lead teacher or educator the opportunity to remedy that, either by providing a common experience through a background investigation or by allowing students choice in what questions they want to answer.

Although it takes more time, we also highly encourage you to give students a voice in deciding what questions to answer and how to investigate them. This student-driven choice gives them ownership over their own learning, helping them to feel empowered and training them to find their own answers in the future.

Designing Learning Outcomes

The Background Research and Media Literacy Model session is an opportunity to support changes in students' ongoing thinking. They are given a chance to think about their models more, and make changes based on questions they had, and new knowledge they have gathered.

Some learning outcomes will relate to the science practices of asking questions and obtaining, evaluating, and communicating information. This step is important because it gives students a chance to practice how to solve problems and answer their own questions.

This is also an opportunity to integrate background investigations. Some of your learning outcomes may relate specifically to content knowledge that you want students to learn, such as describing energy movement through a food web, human impact on ecosystems, etc. If you have students use lateral reading strategies to find answers online, other learning outcomes will relate to checking and evaluating sources students find.

Below, we've suggested some different formats for learning outcomes, depending on what you want your modeling activity to focus on.

Example Learning Outcomes

By the end of this module, students will be able to...	*You can assess this using...*
1. ***Identify*** questions that they have about the marine ecosystem in the Crystal Cove SMCA.	Field notebook entry
2. ***Develop*** and carry out a plan to refine their model of the Crystal Cove SMCA.	Research team models; Field notebook entry
3. ***Describe*** how [energy movement through the marine food web] affects their model.	Summary table entry
4. ***Use*** lateral search techniques to evaluate media sources while conducting background research.	Summary table entry; Research team discussion
5. ***Share*** their newfound knowledge on MPAs with their group and think about how they would revise their model based on what they've learned.	Student discussions; Group discussion
6. ***Reflect*** on why it is important to evaluate the source of information while conducting background research.	Whole class discussion; Field notebook reflections

Possible Links to School Standards

These links are largely dependent on the types of questions that students have. If you choose to have students use lateral reading strategies, there is strong alignment with specific Common Core English Language Arts standards for middle and high school students.

Common Core English & Language Arts

Grades 6-8

- ***CCSS.ELA-LITERACY.RST.6-8.1:*** Cite specific textual evidence to support analysis of science and technical texts.
- ***CCSS.ELA-LITERACY.RST.6-8.8:*** Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

Grades 9-10

- ***CCSS.ELA-LITERACY.RST.9-10.1:*** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
- ***CCSS.ELA-LITERACY.RST.9-10.2:*** Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.

Grades 11-12

- ***CCSS.ELA-LITERACY.RST.11-12.2:*** Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

How to Plan the Learning Sequence

As you start to develop a learning sequence for ***Session 3: Background Research & Media Literacy***, you will need to make several major decisions:

- Develop driving questions
- Decide how to have students identify their questions about their model
- Decide how to have students answer their questions
- Choose how to scaffold students during background investigations
- Decide how to support students in revising their model
- Decide how to support students in developing a hypothesis (if applicable)

Each component will be described below with tips and examples to help you create your own learning sequence.

Develop Driving Questions

As you begin to develop your session, you'll want to select driving questions to direct the investigation for students. These driving questions give students an idea of what they'll do and learn during the session.

Some example driving questions include:

- What else do we need to know to refine our model of our local MPA?
- How can we find the answers to our questions?
- How can we determine if an information source is reliable?

Decide How Students Identify Questions About Their Model

As you get started, you'll want to think about how to guide your students to identify and record questions they have about their models. We've found that it's helpful to give students time to review their models and identity questions they still have.

Some example guiding questions for students are:

1. What were you unsure about in your model?
2. What do you want to learn more about?

During this session, we encourage students to create different summary tables in their field notebook to help keep track of their research and thinking along the way. This keeps a record of their ideas and helps them formulate a plan. It is also a good tool for assessment and to check student understanding.

To get started, you might have students set up a simple table to brainstorm their questions:

Questions We Have...	*How We Plan to Answer Them...*

Decide How to Have Students Answer Their Questions

Once students have had a chance to identify their questions, the next step is determining how to answer them. You can decide how much freedom you want to give students in developing a plan to determine the answers. For older students -- especially if you're planning to have them use lateral reading to look up answers online -- you might allow them to develop their plan independently. For younger students, or if you have specific background investigations in mind, you might choose to develop this plan as a class.

To have students answer their questions, you can choose between two different approaches: Background Investigations or Lateral Reading. Below, you'll find the pros and cons of each.

	Background Investigations	*Lateral Reading*
Description	Background investigations involve hands-on activities focused on specific topics to help students learn more about a particular question. You can often adapt other existing science lessons into background investigations for your program.	Lateral reading is a technique used by fact checkers to quickly determine the credibility of websites by reading laterally. This means that they open multiple tabs in their browsers to read what other sources say about the website.
Pros	Allows students the chance to conduct hands-on investigations and expand their knowledge. Much more engaging for younger students.	Teaches older students about media literacy and how to check sources they find online. Can be assigned out to occur outside of class.
Cons	Can be time consuming to plan different investigations with students, and also time consuming to execute.	Takes some time to explain and practice. Does not work well for elementary students.

Choose How to Scaffold Students During Background Investigations

As students prepare to start answering their questions, we recommend having them set up a second Summary Table in their field notebooks. This table will allow them to keep track of what they've learned so that it's easy to update their model at the end of their investigations.

The Summary Table may look something like:

Question	*What I Did*	*What I Learned*	*Clues for Our Model*
What question are you trying to answer?	How did you find the answer to the question?	What did you learn that answered the question?	What do you plan to add to your model as a result?

If you're having students solely use Lateral Reading strategies, you may ask them to use a modified version of the Summary Table:

Source Title & Format	*Three Lateral Searches*	*Author Perspective*	*Key Ideas*	*Clues for Our Model*
What was the title of the source? What format was it? (i.e., news article, wiki page, YouTube video, etc.)	To assess your source, search for the author (if noted), the publishing organization or website, and 1-2 mentioned experts or organizations. **1.** **2.** **3.**	Is there any information about the author or organization that you should keep in mind while interpreting the source?	What did you learn that answered the question?	What do you plan to add to your model as a result?

If you would like an example on how to introduce lateral reading to students, check out our slideshow from ***Session 2: Asking Questions About MPAs***. In there, you will also find a ***screencast*** that demonstrates the process.

Decide How to Support Students in Revising Their Model

Finally, you will need to decide how to help students take what they learned in their research and apply it to their models.

Especially with younger students, it can be helpful to give them sentence starters to plan their updates. Some example sentence starters include:

- **Add a new idea**: "I think [evidence from your chart] _____________ tells us that I should add ________________ to make my model more accurate."
- **Revise part of an idea:** "I think [evidence from your chart] ________________ supports part of my model, but I would like to change ________________ to make it more accurate."
- **Remove an incorrect idea:** "I think [evidence from your chart] _________________ contradicts _____________________ in my original model, and I want to [remove or revise] it."
- **Identify a question:** "I still have questions about ______________________."

Once students have developed a plan, they can move forward with revising their models!

If students need to update physical models, we recommend using color-coded sticky-notes to represent a different type of comment or idea a student wants to make on the model. The notes can be placed directly onto the model, without making the model get too busy, and getting other ideas overwritten.

Decide How to Support Students in Developing a Hypothesis (If Applicable)

If your program involves comparing different treatments, you may also choose to have students develop a hypothesis. We usually only include this if the research project is set up as an experiment where we're manipulating a variable (which, as noted previously, is not currently allowed in California's MPAs). For monitoring projects, where we're measuring change over time but there is no experimental manipulation, it is not typically appropriate to make a hypothesis.

If you want to have students develop a hypothesis, we recommend giving them a scaffolded sentence framing to help them formulate their prediction:

- If we *[do something]* ....
- Then *[what you think will happen]* ...
- Because *[why you think it will happen]* ...

Learning Sequence

This session usually takes at least 60-90 minutes, but it can be much longer depending on how many background investigations you want students to take part in. We recommend breaking it into two or more sessions, with the first focused on brainstorming questions and the second involving background investigations or lateral reading.

If students are using lateral reading to answer their questions, that task can be assigned as homework and done independently.

Launch

Getting Started (10-20 minutes)

1. Welcome students to the program! Briefly welcome them to the local MPA and introduce the big problem that they'll help solve.

- What questions do you have about your model?
- How can you answer those questions with your research teams?

Explore

Part 1: Identifying What We Need to Know (20 minutes)

1. Ask students to review their models from Session 2 with their research teams. As they do so, they should identify 3-5 questions that they still have.

2. Ask them to set up a chart in their field notebooks to keep track of their questions, then break students into their research teams.

3. Give the class 10 minutes to identify their most important questions. If possible, give them a two-minute reminder before the end of the brainstorming time.

4. Depending on how you are planning to have students answer the questions, you may give them additional time to plan their next steps, or bring the class back together to summarize their questions and come up with a plan as one big group.

Part 2: Conducting Background Research (30+ minutes)

1. Once students have identified their questions and you've agreed on a plan to answer them, have them set up a Summary Table in their field notebooks

2. Next, it's time for students to answer their questions. This could involve giving them time to use lateral reading strategies to answer the questions on their own, or inviting them to take part in background investigations.

3. As students conduct lateral searches or take part in investigations, ask them to keep track of their work and thoughts in their field notebook summary table.

Share

Sharing Our Findings & Revising Our Model (20-25 minutes)

1. Once background research is complete, have students return to their research teams. If they've been working independently, give them 15 minutes to briefly share the results of their background research.

2. When they're ready, explain how you want them to come up with a plan to revise their models. You can share the sentence stems and then let research teams develop a plan individually. With lower elementary students, you may discuss how to do this as a whole class.

3. Once students have developed their plans to update their models, give them access to the models from Session 2 and invite them to make the changes. If possible, move between the discussions. Invite students to share how their thinking and understanding changed as they conducted the background research.

Reflect

Reflecting on the Session (5-10 minutes)

1. At the end of the session, ask students to spend a few minutes reflecting on their experience today in their field notebook or another journal.

- What did you do today?
- What did you learn? How did your thinking change?
- What changes did your research team make to your model? Why?
- How has your thinking changed as a result of your background research? Why do you think it's important for scientists to revise their models?

Resources

- *Stanford History Education Group*
- *Crash Course*
- *How to Read News like a Fact Checker*
- *Tools for Ambitious Science Teaching: Face to Face Tools*
- *Science and Engineering Practices in the NGSS: Obtaining, Evaluating, and Communicating Information* (Page 15)

Reflect

- How does conducting background research support student learning?
- How will you support students in identifying their questions about their model?
- What techniques will you use to help students answer their questions?
- What scaffolds will you give students to help answer their questions?
- How did you support students in revising their models?

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Session 4: Collecting Data

Education Program Structure

Collecting data is often the most exciting part of taking part in a community science project!

Data collection is also an opportunity to engage students in science practice. When participants collect data, whether virtually or in person during a field trip, they are able to make observations about the ecosystem. Scientific equipment can even make it possible to observe parts of the system that are normally hard to see. The data that they collect can be then used as evidence to revise their models to construct an explanation.

However, it is also important to consider data quality. Many researchers and community science managers are rightfully concerned about whether they can trust student-collected data. This creates a tension between balancing the student learning experience with making sure that participants collect data that is reliable. In this document, we'll give suggestions on how to support students in collecting high-quality data, as well as how to design data collection experiences that support learning outcomes.

What Students Will Do

During ***Session 4: Collecting Data***, students take part in an in-person or virtual field trip to the local MPA and collect data for your MPA community science project!

First, student research teams learn about the process of data collection, including what they need to know for their in-person or virtual field trip. After their training, they take part in an excursion to the local MPA, where they collect data and contribute it to your MPA community science project.

To see what this looks like in practice, check out the ***Preparing to Collect Data*** and ***Collecting Data sessions*** in Crystal Cove Conservancy's MPA Exploration program.

Balancing Data Quality & the Student Learning Experience

Whenever you talk to researchers about getting K-12 students or other young learners involved in community science projects, their first concern is often about the quality of student-collected data.

We believe strongly that if we want students to meaningfully contribute to community science monitoring, we have to design first for data quality. If student data can't be trusted, it undermines the idea that they're taking part in real scientific research. This means that if you have to decide between these trade-offs, we strongly recommend prioritizing data quality first.

That being said, there are strategies you can use to scaffold data collection for young scientists and check for data quality so that students collect reliable data that scientists can trust.

These strategies include:

- Providing hands-on training for students and educators in advance.
- Designing scaffolded student data sheets and protocols to ensure that students are recording data accurately and checking their measurements as they go.
- Creating a process to double-check student accuracy, whether it is comparing their measurements to experts or keeping a back-up of video or photo data where possible. As you go through this guide, we'll discuss each of these strategies and share our best tips for ensuring data quality!

How This Session Supports Diverse Learners

Visiting a local MPA or other outdoor site to collect data is an exciting and memorable experience for nearly all students. It also gives them a chance to verify their identity as science practitioners and gives them more ownership in the program they are taking part in.

As you design this session, you may want to think specifically about how to scaffold the experience for learners who have not had previous outdoor experiences. For example, if your community science program takes place on a boat or at the beach and you know that many of your participants may not have been in that environment before, it can be helpful to give them a way to experience it virtually before coming out so that they know what to expect.

Similarly, we've found that it's helpful to introduce data collection protocols in the classroom before the field trip. This allows students to be familiar with procedures and equipment even though they might be in a new environment. When we design data sheets or protocol, we try to include pictures and diagrams as directly as possible, so that students do not need to flip between multiple pages.

Finally, keep in mind that you may want to build in time for students to enjoy their experience! We ask research teams to specialize in one aspect of the monitoring project, rather than rotating them through several different stations. This allows students to master a particular set of protocols, while also giving us more time during the field trip for students to relax with their classmates and appreciate their time in the local MPA.

Designing Learning Outcomes

The process of data collection involves collecting real-world evidence that will help students answer the original research question. Whether this experience happens in person or virtually, it gives participants an opportunity to make observations or take measurements in the real world. Although the data that each student collects is often only one data point within a bigger set, it also gives them the chance to start thinking about patterns. Ultimately, they'll be able to relate these patterns back to the model that they created and refined in Sessions 3-4.

It is easy for data collection to focus on procedural understanding, as students follow a series of steps in a protocol to collect data. Although this procedure is important -- especially in terms of ensuring data quality -- it is helpful to have students make connections between what they notice and larger patterns within the ecosystem.

Example Learning Outcomes

By the end of this module, students will be able to...	*You can assess this using...*
1. ***Describe*** the process of collecting scientific data for the monitoring projects.	Student discussions; Field notebook reflections
2. ***Follow*** protocols and record data for a community science project.	Data collection forms; Educator observations
3. ***Discuss*** whether the data they collected reveals any patterns about what might be happening.	Student discussions
4. ***Reflect*** on how the data they collected can help to answer the larger research question and brainstorm their next steps.	Student discussions; Field notebook reflections

Possible Links to School Standards

Since this session largely focuses on procedure, we recommend linking your learning outcomes to the NGSS Science & Engineering Practice centered on Planning and Carrying Out Investigations. Depending on your project, you can also think about linking to Cross-Cutting Concepts by having students reflect on patterns that they notice in their data.

We've listed a few possible links that you might consider below.

Next Generation Science Standards

Science & Engineering Practices

- Planning and Carrying Out Investigations

Cross-Cutting Concepts

- Patterns
- Cause and Effect

How to Plan the Learning Sequence

As you start to develop a learning sequence for ***Session 4: Collecting Data***, you will need to make several major decisions:

- Develop driving questions
- Decide what data students need to collect
- Develop a plan to validate student data
- Create materials to train students, staff, and volunteers to collect data
- Design a student-friendly data form
- Plan out questions to help students think about how their observations connect to the bigger system

Each component will be described below with tips and examples to help you create your own learning sequence.

Develop Driving Questions

As you begin to develop your session, you'll want to select driving questions to direct the investigation for students. These driving questions give students an idea of what they'll do and learn during the session.

Some example driving questions include:

- What kind of data do we need to collect to answer our research question?
- How can we collect that data?
- What can we do to ensure that our data is trustworthy and reliable so that scientists know they can use it?

Decide What Data Students Need to Collect

As you're considering how to have students collect data, your first step is to decide what data students need to collect. This depends largely on your community science project. Depending on your flexibility, it may also be informed by the research question that they are investigating.

Often, we've found it's helpful to limit the data that each research team is responsible for collecting. For example, in the MPA Exploration project, each class collects data on fish populations, water quality, and plankton biodiversity, but we structure the program so that each research team focuses on only one project. This allows student research teams to become "experts" on their specialization so that they're familiar with one set of protocols. It also gives them more time for discovery and conversation amongst their team, so that they can take the time to collect data accurately.

On the next page, you'll find a chart that gives examples of each different type of research question, the age groups that work best with each category, and a summary of how each category of research question might inform your research design, data collection, and data analysis.

Decide How to Support Students in Brainstorming, Sorting, and Prioritizing Factors

Once you've developed a modeling question, the next step is to decide how you want students to brainstorm and sort the factors to include in their model.

To drive brainstorming, we provide students with an adapted version of our modeling question, switching "How" to "What." For example, we might adapt the first modeling question to read, "What biotic components, abiotic components, and processes affect the biodiversity of fish in the Crystal Cove SMCA?"

Giving students specific categories to sort their factors gives them a framework for their brainstorming. We commonly use biotic factors, abiotic factors, and processes in our modeling sessions, but other options work too. You might choose to sort environmental factors versus human-created factors, or something entirely different. Depending on your model, you may also want to encourage students to think about categories instead of getting too specific. For instance, it may be simpler to use "predators" as a blanket term, instead of brainstorming every possible species.

Once students brainstorm their list of factors, it is also helpful to give them time to prioritize their list. Often, we've found that students will focus on exciting ideas (like great white sharks) that might not have a huge effect on the model itself. We usually ask students to choose the 5-10 most important factors to include in their model.

Research Question Categories	Age Groups	Example Research Questions	Research Design	Date Collection Approaches	Data Analysis Approaches
Classifying Observations	Lower Elementary	What is the most common type of trash on the beach of your local MPA?	The research design might be simplified to only look at one physical sample.	Collecting physical samples	Sort samples into simple categories and count the number in each category.
	Upper Elementary	How many total species of birds are on the beach in the summer and winter in your local MPA?	The research design might include ideas about randomization or contributing to a larger data set.	Make observations or collect samples	Sort samples or observations into categories. Create a bar graph comparing the total number for each category.
Comparing Different Conditions	Upper Elementary, Middle, or High School	If we measure the size of owl limpets in tidepools with lots of visitors and tidepools with few visitors, where will they be bigger?	The research design could be set up as an observational study with different treatments. It could also be a randomized experiment (though CDFW currently does not allow these inside MPAs in California).	Make observations or take measurements	Calculate the mean or median to represent a group of numbers. Create a bar graph to compare means or medians. Use standard deviation to look at statistical distribution.
Analyzing Change Over Time	Middle or High School	How is the total number of fish species in our local MPA changing over time? If we compare the number of fish species in our local MPA to an area outside the MPA, how are they changing over time?	The research design can be set up as an ongoing observational study over months or years. It might involve comparing different treatments, such as comparing different places.	Make observations or take measurements	Create a line graph to look at change over time. Create a scatter plot and add a line of best fit to look at the trend over time. Calculate R^2 value to think about statistical variability.
Mapping Spatial Distribution of Data	Middle or High School	Where are human activities concentrated in our local MPA at different times of year? Where are the most fish present in relation to local MPA boundaries?	The research design might involve making observations within a particular place, or comparing different treatments, such as comparing different habitats or times of year.	Take GPS points of observations.	Calculate distance between GPS points and another location (like an MPA boundary). Create a GIS map showing the spatial distribution of data. The map may involve different-colored layers to compare different treatments or categories.

Develop a Plan to Validate Student Data

Once you've decided what data students need to collect, your next step is to decide how you'll validate student data.

There are some different strategies that you can use to do this. Ideally, you'll want to talk directly to the researcher involved in your community science project and ask them to help you come up with a plan to validate data quality.

Some strategies that we've found to be effective include:

- Inviting students into the data quality assurance process
- Training students on protocols in advance
- Recording screencasts or videos of sample analysis
- Coming up with a protocol to isolate unexpected findings in a sample
- Having multiple student teams record the same data so that you can cross-check their findings
- Having students check their data for outliers using a number line on the data form
- Having experts take a subset of the same measurements so that you can compare them to student measurements to test for accuracy

For our programs, we've found that the most effective tool for ensuring data quality is letting students know that scientists want to use their data. The students themselves are often the best at ensuring that their research team stays focused on the task at hand. By inviting them into the process of determining if their data is reliable, they'll be an eager set of eyes helping to note any issues for you.

We also do what we can to put data quality assurance measures in place. We provide materials for students to practice collecting data in advance, and save the videos of plankton and fish samples that were recorded by students so that experts can review them later. We also have multiple student teams record water quality data so that if one team reports an outlier reading, we can cross-check their data with the other two teams.

You may also consider inviting experts on your first few field excursions to validate student measurements. During our fifth grade community science program, we've performed tests where we've asked fifth grade students, professional field technicians, and university undergraduate interns to measure the same plants so that we could check data quality. (Interestingly, we found that there was no significant variation between the fifth grade student measurements and the professional measurements, but the undergraduate interns were less accurate!)

Finally, we've found that number lines are a particularly useful tool to help students check for outliers in their data. It is easy for students to make small errors while collecting and recording data in the field, such as forgetting to use centimeters or reading an instrument incorrectly. To help catch the errors, we have students place their data on a number line to visually see how the numbers are grouped. If a data point is much further off than others, students can go back and re-take that measurement or double-check to see if anything went wrong. We worked with a PhD student from University of Irvine on the effectiveness of this approach, and she discovered that there was an improvement in student data quality when number lines were used versus when they were not.

Whatever you decide to do, we recommend putting together a written plan on data quality assurance.

Create Materials to Train Students, Staff, and Volunteers to Collect Data

Training students, staff, and volunteers on how to collect data is a very important step to ensure you are getting quality data!

If you have time, we recommend dedicating a separate session to training before students take part in a field trip. Making sure that students understand how to use the scientific equipment before they are out in the field reduces the risk that they'll get overwhelmed during their field excursion. Training can take the form of taking practice measurements, watching video demonstrations, or short, fun identification practice.

You can see an example of this in ***Session 5: Preparing to Collect Data***.

If preparing students before the field trips is not an option, we recommend including time during the field trip for students to practice data collection before they do it for real. It's helpful to have someone demonstrate each step of the data collection process. For older students or parent chaperones, it can also be helpful to develop written protocols that clearly define the step-by-step data collection process.

Finally, we've found that it is also important to plan time to train your education staff or volunteers on data collection. They should be trained on how to use the equipment, how to support students, and how to make quick fixes to equipment if anything breaks. In addition, it is also key to emphasize to staff that it is very important that students completely fill out their data sheets. If parts of the data sheet are left blank (especially date and collection times), it can make the data unusable. Train staff to look over the data sheets to verify they are complete before the end of data collection.

Design a Student Friendly Data Sheet

Believe it or not, your data sheet can have a big effect on the type of data that students collect! As we've experimented with different data sheet designs, we've found a few strategies that have helped to ensure that students record the most accurate data possible.

These strategies include:

- Make sure there is a clear place for student names, date, and time of data collection at the top of the form.
- Use clearly labeled and outlined boxes for each data measurement.
- When recording data that might have several numbers (such as GPS points), include a blank underscore to represent each digit.
- If you are using a clipboard to hold the data collection form, make sure that it is easy to flip through the pages and that the top hinge does not cover any parts of the data collection form.
- To check for outliers, consider using a number line to have students graph data points.

For an example of a student-friendly data form, check out our examples ***here***.

Plan Out Questions to Help Students Think About How Their Observations Connect to a Bigger System

Finally, although data quality is the most important part of data collection, you will ideally want to help students connect their observations in the field to their understanding of the environmental system that they're studying.

To do this, we've found that it's helpful to plan out questions in advance. These questions can be asked by staff or volunteers in the field to help students think about how their data may connect to other teams data and data in the larger data set.

Some example questions:

- What is the goal of our investigation? Why are we collecting data for? What research question are we trying to answer?
- What conditions might affect the data that we're collecting today?
- What does this reading mean? What does it tell us?
- [Water quality monitoring] can be important to other monitoring projects as well. How could the data that you're collecting be used by the other research teams?
- Are there any patterns you've noticed today? If these patterns carry through to the bigger data set, what could they mean?

Finally, do not let students get discouraged if they are not seeing much during their data collection experience. Remember that seeing no fish is still data! Even an absence of observations is still important in terms of a larger data set.

Learning Sequence

Depending on how you decide to design this session, the amount of time it takes can vary quite a bit! We usually plan on 45-60 minutes for students to train on data collection protocols before their field trip, and then a three-hour boat excursion, but this will depend a lot on where your community science program is located, how long it will take students to get there, and how you design your field excursion.

If you're planning to have students collect data virtually, we've found this usually takes around 45 minutes.

Launch

Getting Started (10 minutes)

1. Gather together the student research teams and the following questions:

- Why are we doing research in this particular area today?
- What is the goal of our investigation? What do we want to know about the ecosystem?
- What is our research question?
- Where will our data go?

2. Tell the students that they will work with their research team to complete the data collection. It will be their responsibility to use the equipment safely and accurately in order to collect the data. They will now get a short training on how to use the equipment and how to fill out the data sheets.

Explore

Data Collection Training (30-45 minutes)

1. Tell the students that they will be following specific protocols today to ensure that all of the data they collect is usable for scientists and resource managers. Give them a broad introduction to what they'll be doing, including the research question that they'll be answering, and a short description of how they'll collect data.

2. Ask students to divide into their research teams. Depending on how you're planning to structure their data collection training, give them time to watch a demonstration of the data collection process or to complete the training module.

3. If possible, give students a chance to test the equipment for themselves. As they practice or take part in the training module, move between the teams and make yourself available for questions. Keep an eye for any places where they struggle or seem confused -- this is your chance to correct any errors before they collect data for real!

Collecting Data (30-60 minutes)

1. Once students have finished practicing, it's time to head to the data collection site! Make sure to give them any safety rules in advance.

2. After you arrive at the collection site, give any final safety instructions, and then pass out the equipment and data collection form to students. Have students fill in their names, the date, and the time on their data forms, along with any other initial information (such as weather data).

If you haven't already, make sure to introduce any number lines to the whole group so that students understand how to use them.

3. When students are ready, pass out the data protocols. For younger students, we've found it's helpful to demonstrate data collection one last time in the field! Then, finally, turn them loose to start data collection!

4. As students begin to collect data, check to make sure they are using their equipment correctly and filling out their data sheets. As they work, you can also ask questions to help them connect what they're doing to the broader environmental system.

Some example questions include:

- What is the goal of our investigation? What are we collecting data for?
- What does the number that you recorded mean? What does it tell us about the system?
- Is there anything that might affect the data that you're collecting today?
- Are you noticing any patterns? What could this tell us about the larger system?

5. Keep an eye on student data forms as they continue to collect data. Encourage students to keep checking for outliers or to use their number line.

Share

Sharing Our Findings (15 minutes)

1. When students are done collecting data, give them a few minutes to review what they recorded. If there's time, ask them to check one last time for any outliers in their data.

2. Gather the group together and ask them to share what they noticed:

- What kind of data did you collect? What did you notice?
- Did you notice anything that might be unexpected or out of the ordinary?
- What's our next step for analyzing this data? How can we look for patterns in it to help us answer our research question?

3. During the discussion, make sure to emphasize to students that their data is just one part of the bigger picture. To really determine what's happening in the marine ecosystem, we'll need to collect data again and again over time. That's why the data that they collected will be added to the full data set for our community science project!

Reflect

Reflecting on the Session (5-10 minutes)

1. At the end of the session, ask students to spend a few minutes reflecting on their experience today in their field notebook or another journal.

- What did you learn during data collection?
- Was there anything you found difficult?
- Did you notice anything out of the ordinary?
- What is your next step? How can we use the data we collected today to answer our research question?

Resources

- ***Science and Engineering Practices in the NGSS: Planning and Carrying Out Investigations*** (Pages 7-8)

Reflect

- How can you balance concerns about data quality with student learning outcomes?
- How does data collection support student learning?
- What data will students collect? How will you ensure that it is accurate?
- How will you train students, staff, and volunteers to collect data?
- What will your data collection form look like?
- What questions can you ask to help students think about how their data connects to the bigger environmental system?

Session 5: Analyzing Data

Education Program Structure

Analyzing data to look for patterns is at the heart of science practice.

The process of data analysis allows students to look for patterns in their observations and measurements. It is also closely tied to creating an explanation of the phenomenon that you're studying. Once students have analyzed the patterns in a data set, they can use those patterns as evidence to support a claim about their research question.

As you explore how to design this session, the age of your participants and the structure of your research question will drive the decisions you'll make about how to approach data analysis. If you're working directly with a classroom teacher, it may also be helpful to talk to that educator in advance to learn more about what types of approaches and tools your students may already be familiar with.

What Students Will Do

During ***Session 5: Data Analysis***, students make sense of the data that they collected and develop an evidence-based explanation about what is happening in their local Marine Protected Area.

First, student research teams create visualizations of their data. Depending on the age group, these visualizations could include sorting and counting, creating bar or line graphs, and/or calculating statistical representations of a group of numbers, such as finding the mean or median. For advanced students, this could also include introducing ideas about statistical significance. After constructing a data visualization, students use their visualization as evidence to support a claim about the research question.

To see what this looks like in practice, check out the ***Data Analysis session*** in Crystal Cove Conservancy's MPA Exploration program.

How This Session Supports Diverse Learners

By this point in the program, students have shared a common experience as they've engaged with the phenomenon of how the ecosystem in their local MPA is changing over time and gone through the process of collecting data. In ***Session 5: Analyzing Data***, they'll have the chance to make sense of their observations as they create data visualizations and use those as evidence to develop and support explanations.

In this session, we've intentionally tried to suggest data analysis approaches and tools that are easy for students to use. Avoiding complex data analysis strategies means that students can concentrate on their conceptual understanding, rather than struggling with following complex procedures to create a data visualization. This also allows us to build in more time for students to talk and discuss their ideas as a research team, giving them the space they need to negotiate understanding with their peers.

Similarly to ***Session 3: Modeling***, we've found that it is extremely helpful to provide video scaffolds or screencasts that demonstrate how to use our chosen platform to analyze the data. This breaks up the steps and allows student research teams to move through them at their own pace, supporting students who may not have engaged in this type of work before. In addition, for older students and teachers, we also provide step-by-step written instructions. This support allows all students to worry less about the procedure of creating a graph or visualization and focus more on conceptual understanding.

Designing Learning Outcomes

The process of analyzing data challenges students to think about how best to organize their data in order to best display patterns. Depending on the age of the students that you're working with and the research question that you're having them answer, this could involve different approaches, from sorting and counting to creating data visualizations like graphs or maps.

It is easy for a data analysis lesson to turn into simply following given directions. We try to focus on having students think conceptually about the process of organizing data to look for patterns. This affects the learning outcomes that we include in our lesson design. As well as including outcomes that involve the "doing" of data analysis (such as creating a graph or sorting samples into categories), we also make sure to include learning outcomes that involve thinking about the process of data analysis.

In addition, this session can also introduce ideas about statistical significance by having students think about variability in their data. If you're interested in including this, *How to Plan the Learning Sequence* includes information about how we integrate statistical significance into our data analysis session.

Below, we've suggested some different formats for learning outcomes, depending on how your students are analyzing data.

Example Learning Outcomes

By the end of this module, students will be able to...	*You can assess this using...*
1. ***Reflect*** on how to organize or display their data in order to look for patterns.	Class discussions or observations of student work.
2. ***Sort*** [items] into different categories and count the number of items in each category.	Observations of student work
3. ***Construct*** a visualization of their data, such as a graph, scatterplot, or map.	Student-created graphs or visualizations
4. ***Calculate*** a statistical representation for a group of numbers, such as the mean or average.	Student-created representations
5. ***Develop*** an explanation supported by patterns in their data about [how the ecosystem is changing over time].	Student explanations
6. ***Use*** ideas about statistical significance to determine if there are real differences between two groups of observations.	Student written analyses or class discussions
6. ***Reflect*** on how scientists use data as evidence to support a claim.	Class discussions or field notebook reflections

Possible Links to School Standards

As you're designing your learning objectives, it can be helpful to connect directly to school content standards. As well as Next Generation Science Standards, this session can also be linked to Common Core Standards for Math and to California's Computer Science Standards.

Next Generation Science Standards

It is more challenging to link data analysis of ecological data to specific Performance Expectations from the Next Generation Science Standards, but there are clear links between data analysis and select Cross-Cutting Concepts and Science & Engineering Practices, which are listed below.

Science & Engineering Practices

- Analyzing & Interpreting Data
- Using Mathematics & Computational Thinking
- Constructing Explanations

Cross-Cutting Concepts

- Patterns
- Cause and Effect

Common Core Math

Each grade level has specific Common Core Math standards related to Measurement & Data. We highly recommend looking at the standards for the grade or age level(s) that you expect to work with so that you can get a sense of what students are expected to do with data and graphing at that age.

The Measurement & Data standards are available ***on the Common Core Math website***.

California Computer Science Standards

As of As of 2021, California is in the process of adopting new standards for Computer Science Education. Each grade level includes standards related to data analysis, which may also be helpful in guiding the design of your lesson so that it aligns with content standards.

You can learn more on the ***Computer Science Education Standards website***. If you're from a different state, your own state Department of Education may have their own computer science standards to give you guidance.

How to Plan the Learning Sequence

As you start to develop a learning sequence for ***Session 5: Analyzing Data***, you will need to make several major decisions:

- Develop driving questions
- Decide how to have students analyze data
- Choose a data analysis platform
- Decide how to scaffold the data analysis process for students
- Determine if you want to include ideas about statistical significance
- Integrate scaffolds to support students in developing an explanation

Each component will be described below with tips and examples to help you create your own learning sequence.

Develop Driving Questions

As you begin to develop your session, you'll want to select driving questions to direct the investigation for students. These driving questions give students an idea of what they'll do and learn during the session.

Some example driving questions include:

- Can we find any patterns in out data?
- What does our data tell us about our research question?
- How is the ecosystem in our local MPA changing over time?

Decide How to Have Students Analyze Data

Even when they are very young, children interact with and perceive the world in ways that are rich with mathematics. As they grow older, students' understanding of mathematics and statistical ideas grows more complex.

The structure of your research question will drive how you'll want students to analyze data. To decide on which approach to use, it may be helpful to revisit the Research Design table from the ***Session 4: Collecting Data*** guide!

Classifying Observations

If your research question involves classifying observations into different categories, then for data analysis, you'll want to have students sort their samples into those categories.

If you are working with younger students in lower elementary, it's helpful to have samples that they can physically sort. This could happen at the same point in time when you collect data. You'll also want to keep the number of categories fairly small. Up to five categories is a good limit, but even fewer (two or three categories) is also good for students. You might have students count the total number of items in each category and then write a number to represent it.

If you are working with students in upper elementary, you might have them sort the observations into categories and then create a bar graph on paper showing the total number in each category. Again, you'll want to keep the total number of categories to five or fewer. Note that this process is different from creating a bar graph to compare statistical measures of center: instead of calculating the mean, the bar graph will show the total number of observations in each category.

If you ask students to graph their data, it can be helpful to give them a decision-making tool so that they can decide what type of graph to use. That way, they can start exploring how scientists use different types of visualizations to represent different types of data. For an example of what this might look like, check out our ***Graph Decision-Making Tool***.

Comparing Different Conditions

If your research question involves comparing different conditions, then for data analysis, you will likely want to have students find a statistical measure of the center of each group of numbers and then use that to create a bar graph.

Commonly, we use the mean (or average) as the statistical representation of the center in our programs. With upper elementary students, we often provide them with a shortened data set consisting of 7-10 measurements in each treatment, so that the process of adding numbers together by hand or with a calculator is not overwhelming. Middle or high school students could perform these calculations using formulas in Google Sheets, so they can often handle a larger data set.

After finding the center of each data set, you may have students construct a bar graph of the means as a way to visually compare the different conditions. Again, if you ask students to graph their data, it can be helpful to give them a decision-making tool so that they can start exploring how scientists use different types of visualizations to represent different types of data. For an example of what this might look like, check out our ***Graph Decision-Making Tool***.

Optionally, if you want to have students start to reflect on whether the differences between the treatments are statistically significant, you can have them add in the standard deviation to help them think about how the data is distributed.

Looking at Change Over Time

If your research question involves looking at change over time, then for data analysis, you will want to have students create a line graph or scatter plot.

Line graphs and scatter plots both show change over time. Both types of graphs are very similar, but they have a few unique features:

- **Line Graphs** work better for simple data sets, such as graphing one water temperature reading every month. This may involve calculating the mean reading for each month. Visually, line graphs are fairly easy to read, but they can sometimes oversimplify trends if the data set is large.
- **Scatter Plots** work well for complicated data sets with lots of data points. After creating the scatter plot, you can have students add a line of best fit (or trendline) to look for trends in the data. Although scatter plots can be overwhelming to look at, including each data point can help students think about variation within the data set.

Optionally, if you do have students create a scatter plot and want to have them think about variation and statistical significance, you can also have them calculate the R^2 value, which is a statistical measure of how close each data point fits to the trendline.

Mapping Spatial Distribution of Data

If your research question involves mapping the spatial distribution of data, then for data analysis, you will want to have students create a GIS map of the different data points.

As students prepare to create the maps, they'll need to think about what they're comparing. These might become different color-coded layers to make it easy for others to read and understand their map. This can be done by hand or by using a GIS platform.

Depending on the research question, students may also need to create tables and calculate the distance between their data and a fixed point or boundary.

Choose a Data Visualization Platform

Once you have an idea of what students will need to do in order to analyze their data, your next step is to decide what platform to use.

Creating a Graph

If you'd like students to create a graph, there are a few different platforms available for you to use. Below, we've listed three of our favorites. These range from simple pen-and-paper graphs to visualizations created on specialized online platforms.

	Pen and Paper	SageModeler	Google Sheets
Description	Physical materials using a posterboard, crayons or markers, and post-it notes	Online platform designed specifically for modeling and data analysis	Online spreadsheet tool, similar to Microsoft Excel
Cost	Materials cost	Free	Free
Age Group	Elementary Students (also works for middle and high school students)	Upper Elementary, Middle, and High School Students	High School Students
Pros	Does not require the use of technology or computers. Allows the integration of art. Can take place outdoors or in other locations besides the classroom. Graphing can be done collaboratively with a group of students. Teacher can see thinking in real time.	Really intuitive to use; does not take as much instruction as Google Sheets. Displays all data as a scatter plot, which makes it easy for students to visualize correlation. Teacher can import data ahead of time and share a template with students.	Data analysis can be done collaboratively with multiple students using one online workspace at the same time. Teacher can see thinking in real time. Similar to Microsoft Excel, which is a commonly accepted platform for professional data analysis.
Cons	Requires physical materials. Does not introduce students to advanced data analysis tools. No inherent scaffolds to support student thinking, so the teacher will need to carefully think through the lesson design and student decision-making process.	Only one person can manipulate the workspace at a time (making it harder for students to work in teams). Teacher can only view the contents when the link is shared, so it is hard to watch the process evolve in real time.	It can be challenging to use if students are not familiar with it in advance, meaning their focus is on following steps to create a graph rather than thinking about the graph itself. No inherent scaffolds to support student thinking, so the teacher will need to provide more instructions.

Creating a GIS Map of GPS Points

If you'd like to have students create a map as a visualization, we really like the mapping tool on the ***Common Online Data Analysis Platform*** (CODAP), which is the same platform that hosts SageModeler. Its mapping function allows students to map data and look for patterns.

If you want to do more advanced mapping, the ArcGIS platform offers ***free online accounts*** for school districts and educators, as well as ***free online resources*** to help you get started using the platform.

To see an example of what GIS mapping looks like when it is integrated into a learning experience, check out our ***Gnatcatcher Mapping Environmental Challenge***.

Get Started with Visualization Platforms

For more information on how to use these different platforms, check out the following videos:

- ***Getting Started with GoogleSheets***
- ***Getting Started with SageModeler***
- ***Getting Started with GPS Point Plotter***

Determine Whether to Include Ideas About Statistical Significance

After students have graphed a data set, we've often found that their next question is whether the perceived differences between treatment or trends over time are "real."

When professional scientists analyze a data set, they often consider how confident they are in whether the variation within their data set represents real differences in the real world, or whether these perceived patterns are simply the result of random chance. Scientists use different statistical tests to determine statistical significance.

When we talk about statistical significance with students, we often frame it in terms of variation within a group of numbers. If our data points are grouped close together -- tightly clustered around the mean with clear visual differences between the means of different treatments, or close to the trendline when looking at change over time -- then we can say that the differences or trends are likely to be significant. If there is a lot of variation or overlap in the data, then it is less likely that the differences or trends are significant.
It's up to you if you'd like to integrate ideas about variation and significance into your program. If you'd like to see what this looks like on different platforms, you can check out ***this video***.

Decide How to Scaffold Data Analysis for Students

Once you decide on how you'd like to have students analyze data, your next step is to think through how you can scaffold that process for students. Again, we've found it is helpful to go through the process of analyzing a data set yourself so that you can identify where students might be confused or struggle.

If you are teaching the lesson in person, you will want to plan what directions to give students and how to demonstrate the different tasks. If you are creating materials for classroom teachers to use, you may want to include additional support to help them use your chosen data visualization platform. This could include filming screencasts or videos to demonstrate how to use the platform.

In addition, if you are having students create graphs, it can also be helpful to provide them with a scaffolding tool so that they can decide what type of graph to make. For younger students, you might give them two or three options to choose between, such as a bar graph, line graph, or pie chart. For older students, you might include additional types of graphs, such as a scatterplot. In each case, make sure to give examples of when you'd use particular types of graphs.

For an example of what this might look like, check out our ***Graph Decision-Making Tool***.

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It's up to you if you'd like to integrate ideas about variation and significance into your program. If you'd like to see what this looks like on different platforms, you can check out this video.

Integrate Scaffolds that Support Students in Creating a Scientific Explanation

Once students have found patterns in their data, the last step is to use those patterns as evidence to support an explanation.

Typically in science education, a scientific explanation consists of three parts:

- **Claim:** What you think is happening.
- **Evidence:** Support for your claim. In our case, our evidence will be the patterns that we noticed in our data.
- **Reasoning:** Why you think the evidence supports the claim. This may draw on other ideas that you have about how the environmental system works, such as your model or information in your field notebook.

In science education, this Claim-Evidence-Reasoning format is often referred to as its acronym, CER. Different schools or teachers often have their own CER format or scaffolds for constructing explanations. If you're working with a specific science teacher, it may be helpful to ask them what CER scaffolds they use in their own classroom. If you don't have a version to start with, we've provided an example that you can adapt ***here***.

When you introduce the process of constructing an explanation, we've found that it is helpful to directly review the three parts of a scientific explanation with students. Even if students are familiar with scientific explanations, being very explicit and discussing what sections to include helps them frame their thinking. After creating an explanation, it can also be helpful to give students a chance to give each other feedback on their argument. In the Other Resources section, we've provided some tools that you can adapt to help with this process.

Learning Sequence

Typically, a data analysis session can take anywhere from 45 minutes to 90 minutes for students to complete. If you are working with younger students, you might consider splitting this into two sessions: one focused on making sense of the data and the second on constructing an explanation.

Launch

Getting Started (10 minutes)

1. Share the driving question for the day, and then introduce students to the idea of analyzing data to look for patterns.

- Now that we've collected our data, what is our next step?
- Why do scientists analyze data? How can this help us answer our research question?
- Why would we want to look for patterns in our data? What are some strategies that we might use to create visualizations to make it easier to find patterns?

Explore

Explore Part 1: Thinking about Data Analysis (10 minutes)

1. Divide students into their research teams. Ask them to briefly discuss what they did when they collected data.

2. If possible, share an image of the data on a projector or shared screen. Ask students to share their initial ideas about how they might analyze the data to look for patterns.

As students share their thoughts, elevate data analysis ideas related to what you plan to do. With younger students, you might encourage them to talk about ways that they could sort or count their observations or samples. With older students, this might involve calculating one number to represent a group of numbers (i.e., finding the mean or average) and/or creating a data visualization to look for patterns, such as making a graph or mapping data points using GIS software.

Sorting & Counting

- How could we sort our observations into categories?
- What could we do to see how many items are in each category?

Finding the Average or Mean

- If we have a group of data points or numbers, what could we do to come up with one number that represents the entire group?
- Note that especially with upper elementary students, it is likely that students will suggest other measures of center, such as finding the range (subtracting the smallest number from the largest number) or the mode (taking the most common number). We've found that it is effective to let students continue to share their thoughts until they get to the idea of finding the mean in the exact center of the number set. Students are usually introduced to the idea of an average or mean by fifth grade.

Creating a Graph or GIS Map

- How might we create a visualization of our data that will make it easier to look for patterns?
- If we want to make a graph, what type of graph would work best?
- If we want to make a graph, what might be the independent variable along the x-axis? What might be the dependent variable along the y-axis?
- If we want to map our data, what data points will we map? Where?
- If we want to map our data, how can we differentiate between different groups of data points, such as data collected in different seasons or sightings of different species?

Creating Data Vizualizations (20-30 minutes)

1. Explain or demonstrate to students how they will analyze data. If there are any scaffolding tools that you want students to use -- such as a decision-making matrix to help them decide what type of graph to use to represent their data -- make sure to introduce those tools.

2. If students will be using a new platform to create a data visualization, such as SageModeler or Google Sheets, demonstrate how to use it. (You may also want to provide them with screencasts or written instructions to make this process easy.)

3. Give students time to work. As they do so, move between the groups to check on how they are doing. Encourage them to talk to each other about what they're noticing, and use questions to draw their attention to anything they might have missed (such as labeling the axis on their graphs).

Share

Share Part 1: Sharing Patterns (10 minutes)

1. When the research teams have had time to complete their task, get the group's attention and ask them to share out loud.

- How did you analyze your data? What did you do to look for patterns?
- What kind of graph did you choose to make? Why did you choose that type of graph?
- What patterns did you notice?
- What do these patterns tell us about our research question?

Explore

Explore Part 2: Checking for Statistical Significance (Optional) (30 minutes)

1. Once students have had a chance to analyze their data, you may choose to introduce ideas about statistical significance. Ask students how we might be able to tell if the patterns we're seeing -- whether they are differences between two treatments or groups, or trends in a line graph or scatterplot -- are real, rather than the results of chance.

Give students a chance to share their initial ideas out loud.

2. Once students have shared, introduce the idea of statistical significance. Depending on your data set, there are different strategies that you can use to see if differences are truly significant:

- If you are comparing the means of different treatments, you can find the standard deviation and add it to your bar graph. If the data points are tightly clustered around the mean and do not overlap, then the data is more likely to be significant.

- If you are looking at change over time, you can add a line of best fit to your line graph or scatterplot. If the data points are tightly clustered around the line of best fit, then it is more likely that there is a real correlation between the variables that you are comparing.

3. Demonstrate how students can check for significance, and then give the research teams a chance to explore whether this is true for their data set.

4. Afterwards, give students a chance to discuss what they found out loud and what this means. Sometimes, if there appear to be differences between treatments but a data set is not statistically significant, this may mean that the differences are just random, or that we need more samples or need to monitor change over a longer period of time.

Constructing an Explanation (20-30 minutes)

1. To shift from data analysis to constructing an evidence-based explanation, ask students to think about why we collect and analyze data in science.

- What was the original research question that we were investigating?
- Why do scientists collect data? How can our data help us determine the answer to our research question?

2. Introduce the idea that scientists use patterns in their data as evidence to support claims about what they think is happening in the real world. When we use our data as evidence to support a claim, we're writing a scientific explanation.

If students are familiar with scientific explanations, you can ask them to share the three parts of an explanation. If not, you can go over them together:

- **Claim:** What you think is happening.
- **Evidence:** Support for your claim. In our case, our evidence will be the patterns that we noticed in our data.
- **Reasoning:** Why you think the evidence supports the claim. This may draw on other ideas that you have about how the environmental system works, such as your model or information in your field notebook.

3. For younger students, it may be most effective to come up with an explanation out loud together through discussion.

Have students break back into their research teams. Give them access to their models, their data analysis, and pass out any scaffolds that you're using to support them in developing an explanation and give them time to work and talk together.

4. As students work, move between the groups and listen to their discussions. Pay attention to how they're talking about their evidence and reasoning. If necessary, redirect them to think specifically about the patterns that they noticed in their data (which will be their evidence), and any ideas from their model about how the ecosystem works (which will be their reasoning).

Providing Feedback on Explanations (Optional) (30 minutes)

1. there is time, you can have students give feedback to each other on their explanations to help them strengthen their arguments. This can be set up as a gallery walk, where students write their explanations on large pieces of paper and provide feedback to each other with post-it notes, or by trading explanations with another group and giving structured feedback.

If you do decide to give students a chance to give feedback, make sure to give them a structured way to do so. You'll find some resources to support this in the Other Resources section below.

Share

Share Part 2 (10 minutes)

1. Bring the entire group back together and ask them to share their explanations out loud.

- What is your claim?
- What evidence supports your claim? What patterns did you notice in your data?
- What is your reasoning? Why do you think your evidence supports your claim? Is there anything in your model that shows the connection?

Reflect

Reflecting on the Session (5-10 minutes)

1. At the end of the session, ask students to spend a few minutes reflecting on their experience today in their field notebook or another journal.

- What did you do today? What did you learn?
- What questions do you still have?
- Why do you think it's important for scientists to analyze their data and look for patterns? What role does data play in answering our research questions?

Resources

- ***Science and Engineering Practices in the NGSS: Analyzing and Interpreting Data*** (Page 9)
- ***Providing Feedback on Explanations (coming soon)***

Reflect

- How does analyzing data support student learning? What is the connection to developing evidence-based explanations?
- How will you have students make sense of their data? Is this approach appropriate for their age level?
- What platform (if any) will you have students use as they analyze data? How will you demonstrate how to use it?
- How will you support students as they analyze or graph their data?
- What scaffolds will you provide to help students use their data to support an evidence-based explanation?

Session 6: Sharing Your Findings

Education Program Structure

Both science and learning inherently involve communication.

Whether that takes the form of publishing an article in an academic journal or writing a letter to city council, communicating what has been learned from a scientific investigation allows scientists young and old to share their ideas with colleagues and make their findings public.

This part of your community science program also offers a great opportunity to give students choice in what they do. As you explore how to design this section, you can think about how best to support students in sharing their work. This is a chance for students to share what they've learned with a real audience, whether it's you, your partner scientists or land managers, or your community at large.

What Students Will Do

During ***Session 6: Sharing Your Findings***, students work with their research teams to publish what they've learned from their community science project.

First, student teams choose an audience and a format to share their findings. Next, they identify what they want their audience to learn from their presentation and design their final product, which could take the form of a presentation, a video, a letter, an infographic, or another format that you choose. Finally, they share their final product and reflect on what they've learned throughout their community science program.

To see what this looks like in practice, check out the three social media sessions in Crystal Cove Conservancy's MPA Exploration program: ***Constructing a Message***, ***Finalizing Your Plan***, and ***Executing Your Plan***.

How This Session Supports Diverse Learners

This final session allows students the opportunity to choose how they want to share their findings with their community. We highly encourage you to give students agency by offering them “Voice and Choice” in how they present their findings and who they share it with. This can involve offering multiple options for a final product, such as creating and giving a presentation, writing a letter to a stakeholder, designing a poster or public service announcement, or filming a video.

In addition, this final session is an opportunity to connect back with students’ families and communities. We’ve found that it can be extremely rewarding for students to host their families for an after-school presentation: this allows them to share their newfound identity as science practitioners with their families, and positions their families to celebrate students’ achievements. When students begin deciding how to share their findings, encourage them to reflect on how what they’ve learned might be relevant or interesting for their community. You may also want to consider allowing students to design their final products using the languages that they speak at home.

Designing Learning Outcomes

When students publish their findings, the process involves more than simply presenting their work. The act of formalizing their thoughts and sharing them with others requires students to plan what they want to share and who they want to share it with. This is an important skill set that is transferable to other career areas, including Business, Communications, and more.

Below, we've suggested some example learning outcomes that you can adapt for your program, depending on how you choose to design this lesson.

Example Learning Outcomes

By the end of this module, students will be able to...	*You can assess this using...*
1. ***Choose*** an audience that they want to reach.	Final project
2. ***Identify*** 3-5 key science ideas that they want to communicate about their research.	Final project
3. ***Select*** an effective format to present or share their science ideas with their audience.	Final project
4. ***Report or Share*** their findings, sequencing ideas in a logical manner and supporting their claims with evidence.	Final project presentation
5. ***Reflect*** on the process of science communication and the role that it plays in research.	Field notebook reflections

Possible Links to School Standards

As you're designing your learning objectives, it can be helpful to connect directly to school content standards. As well as Next Generation Science Standards, this session also aligns well with Common Core Standards for English Language.

Below, you'll find some possible connections.

Next Generation Science Standards

There aren't many direct links between communicating ideas about ecological research and specific Performance Expectations from the Next Generation Science Standards, but there is still strong alignment with the last of the Science & Engineering Practices, which you'll find below.

Performance Expectations

- Kindergarten
  - ***K-ESS3-3: Earth and Human Activity.*** Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.

Science & Engineering Practices

- Obtaining, Communicating, & Evaluating Information

Common Core English

Each grade level has specific Common Core English standards related to Speaking & Listening, which includes standards focused on the Presentation of Knowledge and Ideas. We highly recommend looking at the standards for the grade or age level(s) that you expect to work with so that you can get a sense of what students are expected to do with communicating knowledge at that particular grade level.

The Presentation of Knowledge & Ideas standards are ***on the Common Core English website***.

How to Plan the Learning Sequence

As you start to develop a learning sequence for Session 6: Sharing Your Findings, you will need to make several major decisions:

- Develop driving questions
- Consider possible audiences
- Decide on publishing options to offer students
- Create a rubric or other assessment tool

Each component will be described below with tips and examples to help you create your own learning sequence.

Develop Driving Questions

As you begin to develop your session, you'll want to select driving questions to direct the investigation for students. These driving questions give students an idea of what they'll do and learn during the session.

Some example driving questions include:

- What do we want to share about what we found?
- Who do we want to share our findings with?
- How can we share our findings with [our audience]?

Consider Possible Audiences

As you're starting to plan how to support students in sharing their work, you'll want to consider how you can help them identify a meaningful audience. Having an authentic audience helps students feel like what they're doing is real and meaningful, as opposed to creating a product that is only turned into their teacher.

In our community science programs, we often ask students to share their findings back with Crystal Cove State Park, along with any recommendations they have for future resource management. We try to join scheduled presentations in person or on Zoom when we can, both to help students feel like their work is meaningful and also because we learn from their final recommendations.

- Stakeholders in the research, such as partner scientists or resource managers
- Their families or parents
- Their principal
- Local community or government groups, such as City Council
- The broader public
- Another specific audience who might be interested in the research, such as fishermen

It's up to you whether you want to designate an audience for students, let them choose, or some combination of the two.

Decide on Publishing Options to Offer Students

When you frame publishing options to students, it can be helpful to give them a variety of options to choose from. Options might be more limited for lower elementary students, but for older students, we find it advantageous to let them choose between different formats that might appeal to different interests.

Depending on the age level of your students, you may need to think about how to scaffold the publishing process for them. Lower elementary students might write a letter to a scientist together as a class, led by their teacher, and then share it with the scientist over a video call. Upper elementary students might design a poster or create a presentation based on a template. Middle and high school students might be offered more free-form options with less direction.

As you're deciding what options to offer, you may also want to think about how much time students will have to complete their final project. Videos in particular can take a lot more time to plan and execute, and so you may want to think about whether or not to include them.

Some possible publishing options include:

- Giving a presentation
- Writing a letter
- Designing a poster
- Creating an infographic
- Writing a blog post
- Planning a social media post or campaign
- Recording a video
- Planning a live newscast
- Creating a digital story or comic

If you're interested in having students share their thoughts via video, especially with younger students, we recommend using ***Flipgrid***, a free video discussion tool.

Create a Rubric

The final product also offers a great opportunity to assess what students have learned. This could be for a formal grade in class, or it could be for your own internal assessment so that you can see if your program design was effective. A rubric will help you or a teacher evaluate students' final presentations and products.

Even if you're not planning to grade students' work, a rubric offers them direction on what they should include in their final product. It can also be used for students to give each other feedback on their final projects. We usually introduce the rubric for the final project at the very beginning of the unit so that students have a clear idea of what they'll be expected to produce.

If you're giving students a choice in publishing options, it can be helpful to keep the rubric flexible. We also like to look back at our learning outcomes for the entire program to make sure that many of them are reflected in the final rubric so that we can use student work to assess what they've learned.

For an example of a rubric, you can ***check out this example*** from our MPA Exploration program.

Scaffolding the Process for Students

Depending on the age of the students that you're working with, you'll want to think carefully about what kind of scaffolding or supports they might need in order to share their work. If you're working directly with a classroom teacher -- especially in lower or upper elementary -- it can be helpful to find out how the students typically share their work in Language Arts, so that you can provide similar scaffolds for science.

- For lower elementary students, you may want to think about having students design a poster as a research team or write a letter together as a class. Students could also share their thoughts via video using a platform like Flipgrid.
- Upper elementary students could design a presentation, write a letter, give a newscast, or plan and film a video. We've found that it is helpful to provide them with sentence starters to help them think through what to include.
- Middle school and high school students might choose between any of the options suggested above. A well-designed rubric will help guide them to include all of the necessary parts.

In addition to supporting student thinking, you'll also want to think about any necessary scaffolds to help students use technology. For instance, if you want students to film videos, you may need to be prepared to give them instruction on video planning or editing. We've included some resources for this in the ***Resources*** section below.

Learning Sequence

It can take varying amounts of time to have students create their final product. If possible, you may want to plan on giving students at least two sessions to write and design, and then reserve a time for them to share their work.

Launch

Getting Started (10 minutes)

1. Share the driving question for the day, and then introduce students to the final step in their MPA community science project: sharing their findings with others.

- Why is it important for scientists to share their findings?
- Who might we want to share our project with? Why?
- What do we want to share about our project?

Explore

Planning How to Share Our Work (45+ minutes)

1. Give students an overview of what you want them to create. If there are any aspects of sharing their work that you've already made decisions about, such as a format, an audience, or a rubric, make sure to share that information.

2. Have students get into their research teams. Have them start by choosing an audience to share their work with (assuming this is not predetermined).

3. Next, ask students to choose the 3-5 science ideas related to their research that they think are most important to communicate. Give them time to talk and discuss together.

4. Once students have decided what they want to share, share their options for communicating their findings. This could include planning a presentation, writing a letter, designing a poster, or something else.

5. Give students time to work together on their final product. As they do so, move between teams and listen to their conversations. Encourage them to think clearly about what they want to share, including any visuals that may help to tell their story.

Giving Feedback (Optional) (30 minutes)

1. If there is time, you may want to give students an opportunity to trade feedback with another group. Although you can do this in any format that you prefer, we like to set this up as a 3-2-1 Presentation:

- First, Group A spends 3 minutes presenting or reading their work. Group B listens and takes notes.
- Next, Group B spends two minutes giving feedback to Group A. Group A is not allowed to interrupt or ask questions -- they can only respond to clarifying questions from Group B.
- Finally, Group A spends one minute reflecting on Group B's feedback out loud. Group B cannot respond.
- Afterwards, Group A and Group B switch, and the process begins again as Group B gets a chance to present.
- The timing of the presentation can also be adjustable if you think students will need more time to present their work!

2. Once students have had a chance to give each other feedback on their final products, give the research teams more time to incorporate the suggestions into their work.

Share

Sharing Our Questions (10 minutes)

1. For students' final presentation, we encourage you to host an event where students can share their work with a real audience! This could be a community meeting after school, a video call with the scientists that you worked with, or something else!

2. After or at the end of the event, try to meet with students one more time to debrief on the program.

- What was it like to share your findings?
- What worked well? What was challenging for you?
- What role does science communication play in science practice? Why is it important for scientists to share their work?
- What questions do you have about our research project? What would you want to investigate next?
- Why do you think it's important to protect Marine Protected Areas? What role do you want to play in their protection in the future?

Reflect

Reflecting on the Session (5-10 minutes)

1. At the end of the session, ask students to spend a few minutes reflecting on their final experience today in their field notebook or another journal.

- What did you learn from our community science project?
- What questions do you still have about our local MPA
- What role does science communication play in science practice? Why is science communication an important part of science?
- Did you enjoy taking part in community science research? Is this something you might want to do again?

Resources

- ***Science and Engineering Practices in the NGSS: Obtaining, Evaluating, and Communicating Information*** (Page 15)

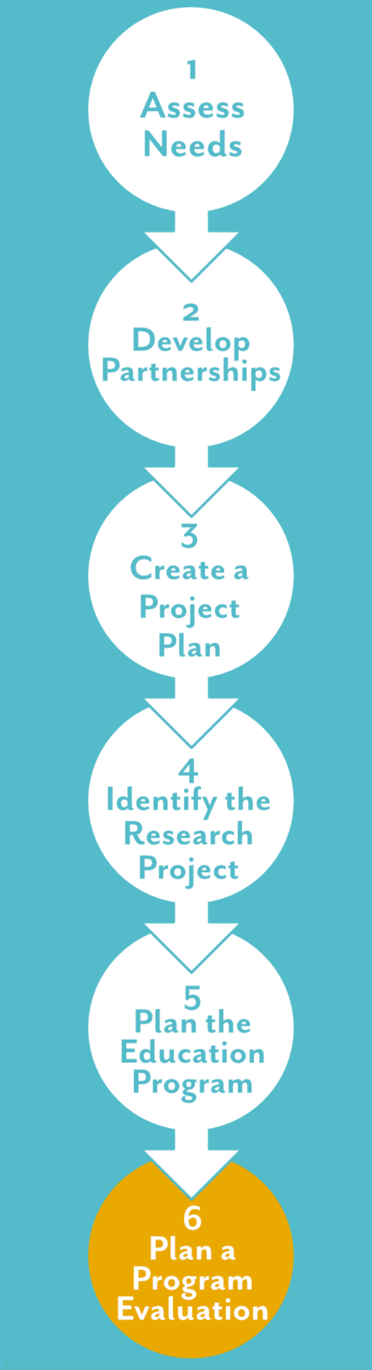
Reflect

- How does sharing their findings support student learning?
- What audience and publishing options will you offer to students?
- Will you create a rubric? What will it include?
- What scaffolds will you give students to support them as they plan how to publish their work?

Crystal Cove® CONSERVANCY

Program Evaluation

Steps to Designing a Community Science Program



While you have been assessing student learning throughout the course of your project, a program evaluation allows you to collect additional data about other areas of your project.

Conducting a program evaluation of your community science project allows you to uncover the strengths and weaknesses of your project and make improvements based on the data that you collect. You can learn more about the needs of your audience and partners through an evaluation and uncover whether your project fulfills their needs. An evaluation can also provide you with information that demonstrates the success of your project, which can be shared with stakeholders and funders.

What You Will Do

As you read through this guide, you will learn more about how to plan and implement a program evaluation. You will have the opportunity to explore online resources that provide detailed guidance on evaluating programs. You'll also find resources for determining if there are instruments that have already been developed that you can use in your evaluation.

By the end, you'll be ready to plan your own program evaluation!

By the end of this guide, you will be able to...

- Describe how program evaluation can help you learn about the strengths and weaknesses of your project.
- Identify other online resources available to help you plan and conduct your evaluation.

Options for Conducting a Program Evaluation

Conducting a high-quality evaluation requires a lot of time and forethought when it comes to planning, implementing, and sharing the results of the evaluation.

There are several options for conducting an evaluation. There are consulting firms that you can hire to conduct an evaluation, but they can be expensive. If you have a partnership with a university, you can talk with them to see if anyone from their School of Education would be available to provide you with guidance on conducting an evaluation.

Even if you don’t have the budget to hire an external evaluator or any formal training in the field of evaluation, there are resources available to help you conduct a solid evaluation that will provide you with data to learn about and improve your community science program. You just need to plan for the time it will take for you to become familiar with the steps of the evaluation process.

Guides for Planning and Implementing a Program Evaluation

The Cornell Lab of Ornithology has produced a ***user's guide*** for evaluating community science projects that provides practical advice on how to conduct a summative evaluation of a community science project. This guide is helpful for anyone who is interested in conducting an evaluation of their project and needs practical advice to help them feel confident and comfortable with taking on the responsibility of conducting a high-quality evaluation. It is comprehensive and written in a way that makes it possible for a novice to conduct an evaluation. The authors have also produced a ***shorter version of the guide*** in an interactive format.

The guide includes a brief overview of evaluation, but the main focus is on providing guidance on the three phases of the evaluation process: Plan, Implement, and Share.

The Plan Phase is divided into three parts: inventory, define, and design. The authors go through these three planning stages in detail with the end result of an evaluation plan that guides the Implement Phase and Share Phase of the evaluation process. They include a framework for outcomes and information on logic models, theory of change, indicators, timelines, the Institutional Review Board process, evaluation designs, and data collection strategies.

In the Implement Phase, the authors describe evaluation instruments, data management plans, and how to test and administer instruments.

In the Share Phase, the authors provide guidance on how to analyze different types of data, describe the components of an evaluation report, provide tips for disseminating the results with external stakeholders, and discuss the importance of using evaluation results to make informed decisions about the project. The guide includes several appendices with helpful resources and templates.

The University of Michigan has created an online portal that provides guidance for conducting evaluations of environmental education programs called ***My Environmental Education Evaluation Resource Assistant (MEERA)***. While this website is not specific to community science projects, it provides a comprehensive look at evaluation and provides step-by-step guidance for the evaluation process.

Resources

The aforementioned resources provide guidance on instruments you can use for your evaluation, but the following resources also provide specific instruments you may want to consider.

- The Cornell Lab of Ornithology has developed a toolkit for measuring outcomes in community science programs. You can review their list of instruments and submit a request to use them at this ***website***.
- The ***PEAR Institute*** has a searchable database of assessment tools that includes descriptions and reviews of tools that can be used to measure performance in out-of-school programs.
- If you would like more information about using assessment instruments, ***InformalScience.org*** has a page that provides helpful information and links to additional resources.

Reflect

- What is a program evaluation? How will conducting one help you understand and improve your program?
- What questions about your program do you want to answer through the evaluation? What information will you need to collect to answer those questions?
- Do you have the capacity within your organization to conduct the program evaluation? Or will you need to hire an external evaluator?

Afterword

Crystal Cove Conservancy would like to thank the ***Ocean Protection Council*** and ***Coastal Quest*** for funding this project as part of their ***Marine Protected Area (MPA) Outreach and Education Small Grants Program***! This grant program provides support to organizations serving underserved communities with the goal of increasing ocean stewardship, engagement, compliance, and leadership. It gave us the opportunity to expand our MPA Exploration program and develop this tool, which will hopefully help you and others like you build on our program model to develop your own MPA community science programs.

Since the launch of our MPA Cruise in 2012, we've wanted to turn it into a model and disseminate our approach all along the coast. In 2015, we worked with ***Central Coast Aquarium*** in Avila Beach and ***WildCoast*** in San Diego to pilot the process of adapting our model to work in other MPAs. In partnership with us, each nonprofit created their own site-specific program to bring students to a local MPA to engage in real research. WildCast has continued to run their own version of this ***program*** ever since. We hope that creating this digital tool to share our model for an MPA community science program will make it easier to share our approach with other organizations!

If you have read through this guide and plan to set up a project on your own, we'd love to help! Please feel free to reach out to our team with any questions or comments -- or just to let us know that you've decided to take this effort on yourself.

Thanks for joining us on this journey. We hope you'll share more about your own unique MPA community science program with us soon!

Sincerely,

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COASTAL QUEST Building Resilient Communities | CALIFORNIA MARINE PROTECTED AREAS | OCEAN PROTECTION COUNCIL

Crystal Cove® CONSERVANCY

Dedication

Our team at Crystal Cove Conservancy is incredibly grateful to all of our partners at Crystal Cove State Park, UC Irvine, Newport Landing Sportfishing, Sacred Places Institute for Indigenous Peoples, the Orange County Marine Protected Area Council, and our participating schools, who have helped continually refine this program model over the past ten years.

You are all a part of our team, and we couldn't do this important work without you. It takes a community.

A special thank you to Dr. Jennifer Long, whose doctoral thesis has become the anchor for our educational design approach; Thor, Jessica, Captain Mike, and the rest of the Western Pride crew, who have been our long-time collaborators at Newport Landing; Lana and Riley, who are exemplar of who we hope our students will become; Angela, Tina, Jessa, Amelia, Joyce, Maritza, Dena, and the rest of the SPI team, who have taught us so much about centering Indigenous perspectives and Indigenous justice in our work; Dr. Al Bennett and The Conservancy's Education and Conservation Committee, who always show us the way; Rossella, Hosun, and Ha, who have taught us so much about learning; Tim, who was our plankton person for years; Dolores and Stephanie, who are always willing to test anything for us in their classrooms with no questions asked; and Harry and Sue, who laid out the vision for this type of community science education program a decade ago.

And finally, our sincere thanks to all of the thousands of students from all over Southern California who have taken part in the MPA Cruise program over the past ten years. We've learned so much from you, and you all give us hope for the future.

Appendix I: Annotated Bibliography

Aside from Crystal Cove Conservancy's guide to setting up your own MPA community science education program, there are lots of great existing resources related to community science!

This annotated bibliography provides an introduction to other resources that are available to support you as you design, develop, and implement your community science project. It is not an exhaustive list of all of the resources that are available, but it focuses on those that are user-friendly, provide practical guidance, and are available for free online.

Each entry includes a description of the resource and suggestions for situations in which it would be most helpful.

A note about the terminology used in the bibliography: Crystal Cove Conservancy uses the term community science to describe projects where we invite non-professional scientists to take part in real-world research. These types of projects are also known as citizen science or participatory science. In recent years, some organizations have moved away from using "citizen science" in favor of the more inclusive "community science." Two organizations have published why they made the change to using community science: ***Natural History Museums of Los Angeles County*** and ***Audubon***.

While this is becoming a more common practice and one that Crystal Cove Conservancy has adopted, the resources below still use the term citizen science.

National Academies of Sciences, Engineering, and Medicine. (2018). Learning Through Citizen Science: Enhancing Opportunities by Design. Washington, DC: The National Academies Press.

A committee of experts conducted a study on how community science projects can be designed to better support science learning and published their findings in this book, which is available as a free download. It provides a comprehensive examination of community science projects and a thorough overview of how community science projects align with science learning.

For readers who are not familiar with the field of science learning, there is a chapter dedicated to the foundational principles of learning. It provides considerations and recommendations that come from research that can be used to strengthen science learning in community science projects, including knowing your audience, using an assets-based approach, designing for diverse audiences, co-designing with stakeholders, and addressing issues of equity and power throughout the process.

This book is helpful for anyone who wants to understand how community science projects can lead to science learning outcomes and anyone interested in incorporating science learning into their project. It can be used when developing a new project or adapting an established project so that it incorporates science learning. The book

provides guidance on how to intentionally incorporate science learning into projects, and it assumes that the reader will synthesize the information and guidance and apply it to their own project. However, it does not provide a detailed planning guide or specific details for setting up a community science project.

Phillips, T. B., Ferguson, M., Minarchek, M., Porticella, N., & Bonney, R. (2014). User's Guide for Evaluating Learning Outcomes from Citizen Science. Ithaca, NY: Cornell Lab of Ornithology.

This guide from a leader in the field of community science, Cornell Lab of Ornithology, provides practical advice on how to conduct a summative evaluation of a community science project. It includes a brief overview of evaluation, but the main focus is on providing guidance on the three phases of the evaluation process: Plan, Implement, and Share.

The Plan Phase is divided into three parts: Inventory, Define, and Design. The authors go through these three planning stages in detail with the end result of an evaluation plan that guides the Implement Phase and Share Phase of the evaluation process. They include a framework for outcomes and information on logic models, theory of change, indicators, timelines, the Institutional Review Board process, evaluation designs, and data collection strategies.

In the Implement Phase, the authors describe evaluation instruments, data management plans, and how to test and administer instruments.

In the Share Phase, the authors provide guidance on how to analyze different types of data, describe the components of an evaluation report, provide tips for disseminating the results with external stakeholders, and discuss the importance of using evaluation results to make informed decisions about the project. The guide includes several appendices with helpful resources and templates.

This guide is helpful for anyone who is interested in conducting an evaluation of their project and needs practical advice to help them feel confident and comfortable with taking on the responsibility of conducting a high-quality evaluation. It is comprehensive and written in a way that makes it possible for a novice to conduct an evaluation. The authors have also produced a ***shorter version of the guide*** in an interactive format.

Shirk J., & Bonney R. (2015). Developing a Citizen Science Program: A Synthesis of Citizen Science Frameworks. Cornell Lab of Ornithology, Ithaca, NY.

This comprehensive look at developing a community science framework comes from a leader in the field: Cornell Lab of Ornithology. Cornell Lab of Ornithology has been developing and implementing projects for years and has taken on a leadership role in the field by producing resources for other organizations to use.

This document provides guidance on developing a framework for community science projects to ensure that they are designed strategically. The guidance is based on information that the authors gathered from interviews with people who have developed frameworks and from foundational documents in the field.

The synthesis of the information led to the five stages of strategic development and implementation that are described in the document: identify goals, establish capacity, design/refine, manage, and apply/adapt. They also found two overarching aspects that play a role in a framework: participant engagement and sustainability/accountability. The authors provide details about these topics and also include resources in the appendices that include examples of frameworks.

This document is helpful if you are in the early stages of considering whether or not to pursue a community science approach and would like to strategically design your project through the use of a framework. It provides guidance on key aspects of developing community science projects, but leaves it up to the reader to decide how to utilize the information to develop their own project.

However, this document does not provide as much detailed, practical advice as can be found in the ***resource from the U.S. Forest Service*** and does not focus on how to design a project that puts STEM learning objectives at the forefront of the design process. For that type of information, please refer to the ***book from the National Academies of Sciences, Engineering, and Medicine***.

United States Forest Service. (2018). Forest Service Citizen Science Planning Guide. United States Department of Agriculture.

This comprehensive planning guide comes from the perspective of the United States Forest Service and their experiences with community science projects. It is a detailed planning guide that provides information on a range of topics, including the basics of getting started, building the team who will work on the project, working with partners (including tribal partners), designing the project and the data management plan, preparing volunteers, planning the evaluation, and sharing the results of the project. It is part of a ***toolkit*** that includes a template, recordings of webinars, and other resources.

This planning guide is helpful if you have already decided to start a community science project and would like specific information about all of the details you will need to do to plan and implement your project. Although it comes from the Forest Service's perspective, it would be helpful for anyone starting a new project. The project plan template included in the toolkit would be especially helpful for anyone interested in creating a comprehensive guide for their own project because the template format makes it easy to enter your own information into the format that the Forest Service has used for their guide.

While this guide provides practical and detailed information about how to design and implement a community science project, it does not focus on how to design a project with a focus on STEM learning objectives. For that type of information, please refer to the ***book from the National Academies of Sciences, Engineering, and Medicine***.

U.S. General Services Administration. (2021, May 27). Federal Crowdsourcing and Citizen Science Toolkit. ***https://www.citizenscience.gov/toolkit/#***

This toolkit from the United States Federal Government is designed to help federal employees plan, design, and implement community science projects, but the five-step process that is described applies to any community science project.

For each of the following steps, the website provides tips in an easy-to-use bulleted list and includes links to other resources that provide additional information. There is also a separate page with the resources grouped by category to make it easier to browse through all of the resource links that are provided.

1. Scope Your Problem
2. Design a Project
3. Build a Community
4. Manage Your Data
5. Sustain and Improve

In addition to the guidance provided for each step, the toolkit also includes a selection of case studies that showcase a range of types of community science projects. For each case study, there is an overview, a project description, how the project addresses challenges (e.g., data quality), benefits and outcomes, and how the case study illustrates components of the toolkit's five step process.

This toolkit is helpful for someone who wants a general guide on how to plan, design, and implement a community science project and has enough previous experience to be able to synthesize the information provided in the tips, resources, and case studies to apply it to their own situation. The information in Step 3: Build a Community would be helpful for anyone who would like to be more intentional about creating and nurturing a community of participants.

However, the toolkit doesn't provide a detailed guide for starting from scratch, so the ***guide from the U.S. Forest Service*** would be a better fit for someone who is less experienced and would like more support going through the process. While it discusses evaluating outcomes, this resource also does not explicitly address how to build a project focused on science learning outcomes.