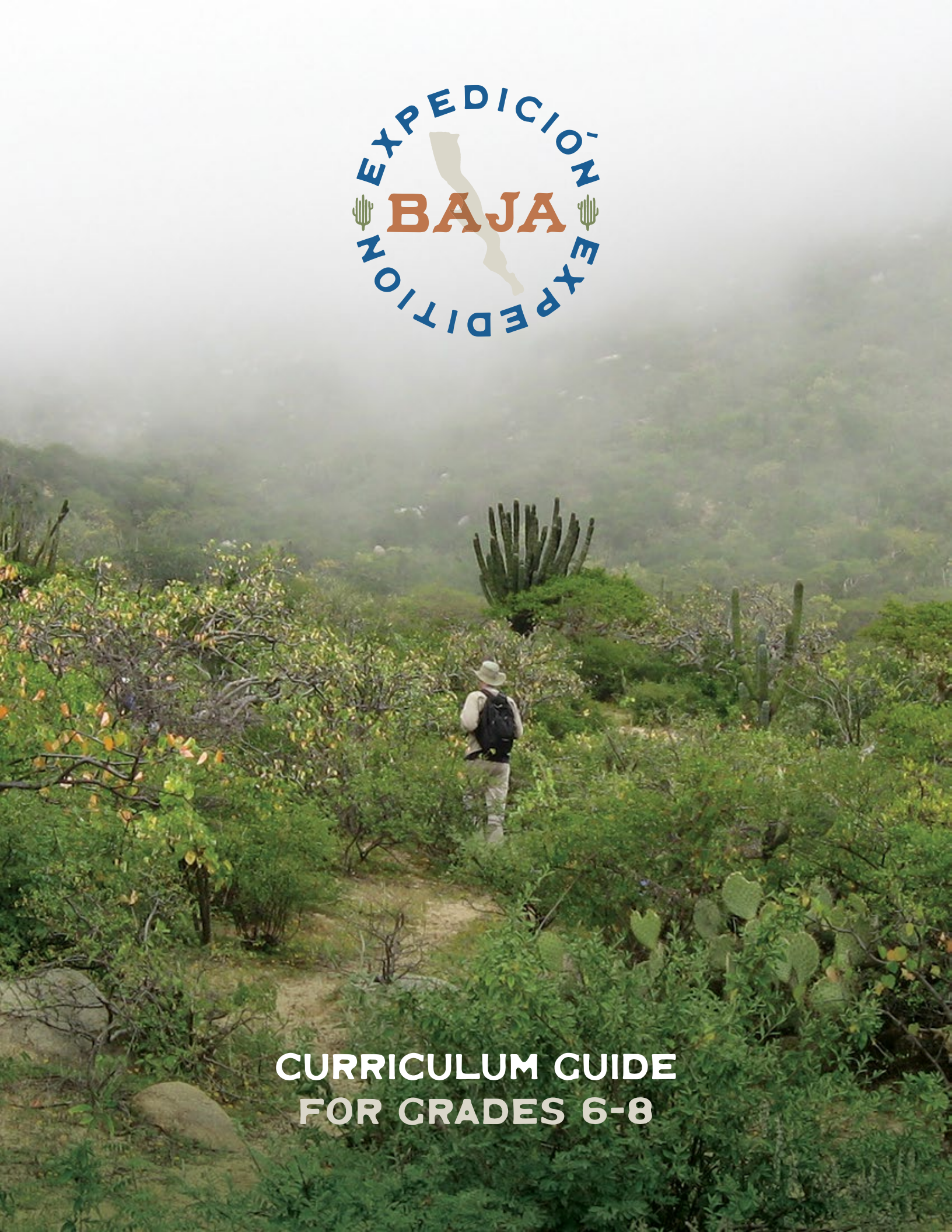


CURRICULUM GUIDE
FOR GRADES 6-8

EXHIBITION OVERVIEW

The Baja California Peninsula is one of the most special places in the world. Surrounded by the Pacific Ocean on the west and the Gulf of California on the east, this 775-mile-long peninsula has a warm climate and diverse terrain, ranging from coastal sand dunes and rugged mountain peaks to desert flats to isolated islands. The varied landscape supports an amazing diversity of plant and animal life—towering cardón cacti, islands crowded with breeding birds, and insects and arachnids with special adaptations to cope with life in the dunes.

The peninsula has been a magnet for adventurers and naturalists, including our own researchers who have been exploring and studying the region for more than a century. Go on an expedition with our scientists as they work alongside colleagues in Mexico to conserve one of the most amazing places on earth.

Expedition Baja curriculum was made possible by charitable grants to the San Diego Natural History Museum from the Americas Foundation and the Ellen Browning Scripps Foundation.

LESSON PLANS OVERVIEW

The lessons in this guide are pre-visit and post-visit activities for middle school teachers to engage with their students on both ends of their visit to the Museum. They provide students with a feel for what it is like to be a researcher in Baja by learning about real-life scientists, engaging in mock data analysis, and discussing how they can be an advocate for conservation.

NGSS Standards

- **MS-LS2-1.** Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
- **MS-LS2-4.** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
- **MS-LS4-2.** Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.
- **MS-ESS3-3.** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- **MS-ESS3-4.** Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

ESSENTIAL QUESTIONS

- **Why is research needed in the Baja California Peninsula?**
- **What types of research are being done in the Baja California Peninsula?**
- **What is it like to be a researcher?**
- **What is science communication and why is it important?**

PRE-VISIT LESSONS

To prepare your students for your visit, it would be helpful to introduce some key concepts and vocabulary prior to your field trip by incorporating the following activities into your lesson plans.

LESSON 1: WHAT IS SCIENCE COMMUNICATION?

OBJECTIVE

Students will determine their definition of science communication and why they think it is important. This lesson connects and prepares students for the post-visit lesson *Shapes and Sizes of Science Communication.*

Materials*

- Whiteboard
- Chart paper
- Tablets to access online discussion platform

**All materials are optional to enhance discussion*

Preparation *(10 minutes)*

Decide what type of conversation format is best for your class. This activity can be done in whatever format your class is comfortable with. Some ideas: Think, Pair, Share; Silent Discussion using a platform like Mentimeter; full class discussion using the whiteboard.

Activity *(30 minutes)*
Engage in a conversation with your students to create a class definition of science communication and why it is important. Ask your class the following questions to guide the discussion *(potential responses/answers are in italics):*

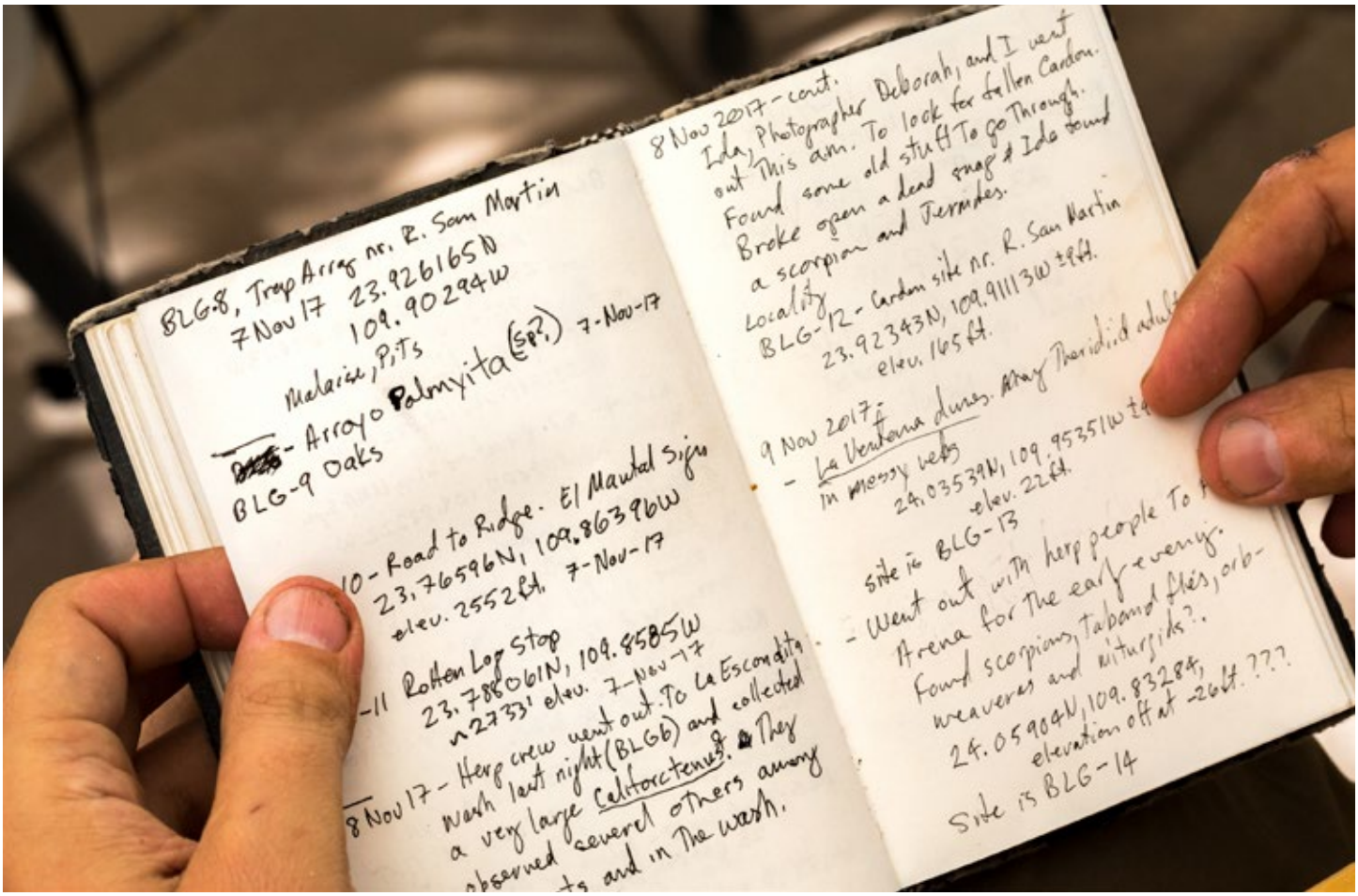
- What are some of the different ways people communicate? *(Talking, sign language, writing, visual cues/body language, art)*
    - Which of these ways could be used to communicate science? *(All of them)*

- What do you think science communication is? *(Definition: a variety of practices that transmit scientific ideas, methods, knowledge and research to non-expert audiences in an accessible, understandable or useful way)*
    - Have you seen science being communicated before? If so, how?

- Do you think museums can help communicate science? If so, how? *(Yes - through field trips, distance learning videos/programs, blog posts, lab demonstrations, social media, etc.)*

- Why is science communication important? *(It has an important role to play in helping people to learn about science, to understand scientific issues when they hit the news and to have a voice in debates about the roles of science in our lives)*
    - Why does science need to be communicated and to whom is it communicated? *(Science topics can be hard to understand for non-scientists, so it is important to educate the public on issues that impact them)*

Write down the definition your class creates and the answers given to the above questions. This will be referred to in a post-visit activity.



LESSON 2: DISCUSSION ON BAJA RESEARCH CASE STUDIES

OBJECTIVE

Students will participate in a dialogue on a research project in small groups and then present it to the class. They will leave with an understanding of the wide variety of research in Baja and why it is so important.

Materials

- 6 Case Study PDFs*
- Vocabulary Definitions*
- Annotating Text Guide*

**See Appendix A*

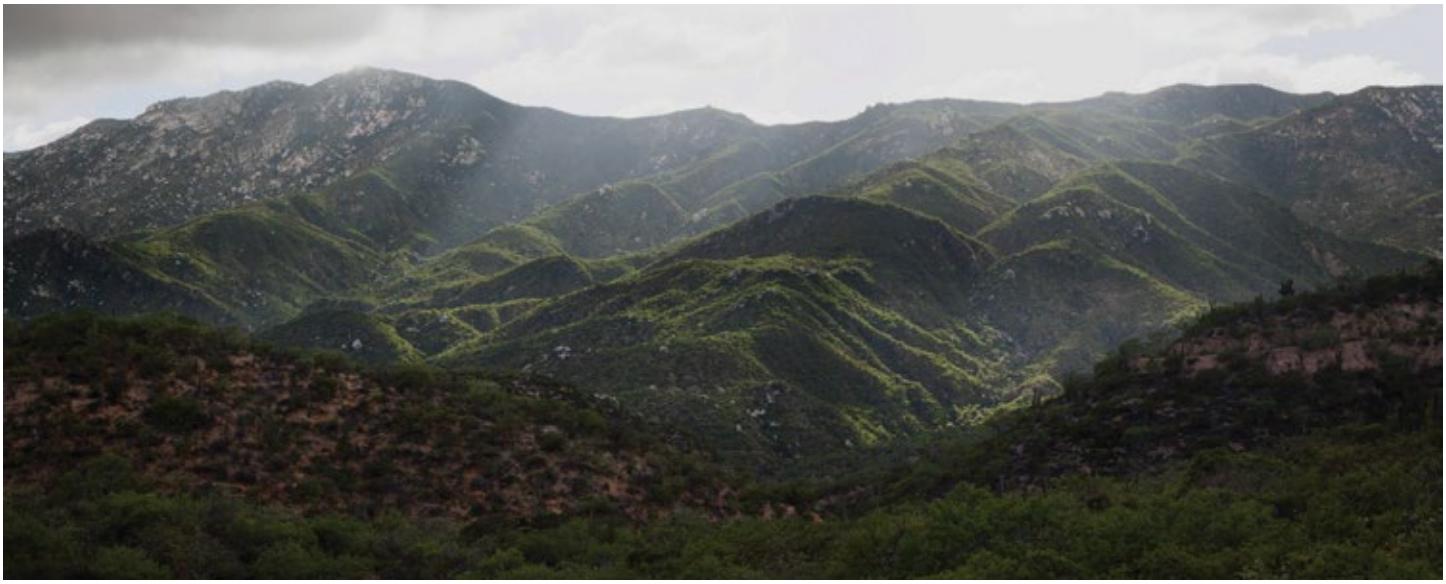
Preparation *(10 minutes)*

- Provide copies of the text and associated vocabulary definitions for each student (printed or digital). *If providing digital text, consider using an online annotating platform like Perusall.*
- Print out Annotating Text Guide for each student
- Arrange student desks or chairs into groups to promote easy discussion.

Keep in Mind

- When students can discuss their own connections and pursue answers to their questions collaboratively, they are able to see that being challenged by scientific concepts is a normal part of reading a scientific text and will increase their confidence the next time.

- It is important that students who struggle or who are intimidated by reading have a strategy for feeling successful as they read, even if they do not finish the entire text. Suggest the goal of recording at least one question about the text and completing one summary (potentially with your help or the help of another student).



Activity *(1 hour)*
Assign case studies to students and group them with other students reading the same text. The texts are using more complex science terminology than students may have seen before, so remind them it is okay if they don't understand everything when they first read through the case study, that is why they will be engaging in a discussion with their peers. There are a few case studies that are more challenging if you have students at a higher reading level.

Students will begin by reading the case study on their own and annotating text to remind them of what stood out to them so they can be prepared to discuss it in their small group. Provide them with a copy of the Annotating Text Guide found in Appendix A.

Once students are done annotating, they will discuss the case study in their group. See below for some guiding questions for student discussions:

1. Were there any words that you didn't understand or were new to you? Come up with a definition as a group.
2. What connections did you see to you or your community in the text? Do your classmates connections apply to you as well?
3. As a group, come up with one or two sentences that highlight what you found most interesting or relatable in your case study. Be prepared to share out with the class.

Have each group share out their highlights to the class.

*This activity can be done Socratic Seminar style if you prefer that method of discussion in your classroom. For more information on Socratic Seminars, download the PDF from this NSTA article.

Extension Activities
- Virtual exhibit tour & virtual lesson
- Watch "Meet the Team" YouTube videos to learn about careers in museums/conservation/research: Meet the Team - YouTube
- Watch career spotlights and recorded talks by our team relating our research in the Baja California Peninsula and our *Expedition Baja* Exhibit

POST-VISIT LESSONS

LESSON 1: SAVING THE RED-LEGGED FROG

OBJECTIVE

What is it like to be a frog researcher? From analyzing frog call audio to predicting how this data will help in the conservation of red-legged frogs, students will get the chance to step into the shoes (or waders) of some of our herpetologists!

Materials

- Tablet/computer and headphones *(for individual listening to audio files)*
- Saving the Red-legged Frog Lab Sheet *(one per student)**
- Frog audio files

**See Appendix A*

Preparation *(20 minutes)*

- Print out Lab Sheets for each student.
- Decide who will be in research teams together *(3-4 students per team).* This will be the group that they will work with for the entire lesson. Each student will fill out their own worksheet, but work as a team to come up with their answers.
- Test out the audio files to make sure they play on your students' devices.

Vocabulary

- **Acoustic** - relating to sound or the sense of hearing
- **Analyze** - examine in detail the structure of something, especially information
- **Population** - a particular section, group, or type of animals living in an area
- **Scientific name** - Scientific names are the universal names for particular species. They tie that organism back to its species descriptions and to its closest relatives. The names are written in Latin and are typically shown in italics. Example: Cat *(Felis catus)*
- **Translocation** - the intentional and planned movement of organisms from one place to another for conservation purposes (to benefit the survival of populations, species, and the restoration, persistence, or enhancement of biodiversity, ecological processes, and habitat)

Activity *(30 minutes per section – we recommend completing these activities over the course of 2-3 class periods)*
As a class, read through the Background Information on the Lab Sheet to learn about the research project.

- This may be a review of what your class learned in the *Expedition Baja* exhibition
- Some words/concepts may need to be defined as a class since the concepts could be new to your students

This activity is broken up into three sections, and all activities can be done in their research teams. First, students will learn the sound of the California red-legged frogs (CRLF) call vs. chorus frogs in order to distinguish whether CRLF's are present in an area. Second, students will analyze frog call data alongside temperature and rainfall data to determine whether physical changes in the environment impact when CRLFs lay eggs. Lastly, students will develop a recommendation for the best next step to conserve the CRLF.

1. **Acoustic Monitoring:** Students will learn the difference between the call of the CRLF and the call of chorus frogs. Then, they will analyze audio files and record on their Lab Sheet whether or not they hear the call of the CRLF in each 1-minute interval.
2. **Analyzing Frog Call Data:** CRLF calls ramp up a few weeks prior to egg masses being laid. Using graphs of call data, rainfall data, and temperature data, students will determine if there is an environmental cue that triggers the CRLF mating season.
3. **Recommendations for Conservation Efforts:** Using the results from their data analysis, research teams will come up with their recommendations for how the data can guide future CRLF research and conservation efforts.

Extension Activity
Check out the Amphibian and Reptile Atlas of Southern California with your class. Under the Learn tab, select Biodiversity to learn about the diversity of herps (amphibians and reptiles) in Peninsular California. This is a great resource for students that are doing their Lesson 4 project on a reptile or amphibian.

LESSON 2: EXPLORING ISLAND ADAPTATIONS

OBJECTIVE

Students will investigate some unique adaptations of various 'island species' found in Baja. They will develop their own explanations of why dune and high mountain species have unique adaptations similar to those of species found on islands.

Materials

- Exploring Island Adaptations Species Cards *(one set per research team, print in color)**
- Exploring Island Adaptations Lab Sheet *(one per student)**

**See Appendix C*

Preparation *(10 minutes)*

- Divide students into research teams of 3-4 students
- Print out sets of the Exploring Island Adaptations Species Cards for each team *(if preferred, these can also be provided digitally)*
- Print out copy of Lab Sheet for each student

Vocabulary

- **Adaptation** - a change or the process of change by which an organism or species becomes better suited to its environment
- **Endemic** - (of a plant or animal) native and restricted to a certain place

Activity (45 minutes)
In their research teams, students will compare and contrast related 'island' and mainland species using the Species Cards provided. You can have every research team look at all Species Cards or, if you are short on time, you can give one Species Card to each research team and have them present their findings to the class.

In this activity, the term 'island' encompasses both the traditional meaning of island (land surrounded by water), but also two other unique definitions of island species. These include 'sky island' species, or ones found atop very high mountains, and dune species, or species found in the middle of wide expanses of sand. Both sky islands and dunes have high endemism, just like traditional islands. This means they have many species that can be found nowhere else and are uniquely adapted to life in that specific area. Sometimes a habitat can be so different from surrounding areas that it is like an island (ex. oasis of water in the middle of a dry desert).

It will be your students' task to identify the unique adaptations of the 'island' species and create a theory for why each species adapted the way it did. See below for some answers for each species, but keep in mind that your students may come up with a different theory than the ones listed, and that is welcomed!

- **Isla Santa Catalina Rattlesnake** – Scientists believe there are three possible reasons for why the snake has no rattle: there are no predators to scare away, to sneak up on sleeping prey, or random genetic changes
- **Long-clawed Sand Scorpion** – Adapted to have many small hairs on its body and legs that help them walk and dig in the ever-shifting sands of the dunes. Sand dunes in the Vizcaino Desert are islands of loose wind-blown sand surrounded by rocky desert. Like an island, some species in the dunes are so specialized to living there that they can't survive in the surrounding "sea" of rocky desert.
- **Guadalupe Caracara** – Many island birds, like this one, are adapted to having more dull coloration than their mainland counterparts. Scientists hypothesize this could be due to the lower levels of genetic diversity in island populations, causing less color variation. An alternative hypothesis is that island birds invest more in caring for their young than in bright colored plumage.

LESSON 3: HUMAN IMPACTS AND HABITAT RESTORATION

OBJECTIVE

Students will engage in problem-based learning activities about ecological issues in Baja California and devise solutions for the issues presented.

Materials

- Introduction to Problem-Based Learning*
- Problem Activities*

*See Appendix D

Preparation *(1 hour)*

- If you have not engaged in problem-based learning with your class, read through Introduction to problem-based learning. We recommend reading over the following pages: vii-viii, 17-36, 45
- Read through the Teacher Guides for the two Problems and select the one you would like to engage your class with first. They can be done in either order, or you can just do one if you have time constraints.
- Print out the Activity pages (one-sided) for each student, so that you can give the pages one at a time as you go through the Activity
- Keep in mind that these activities are meant to be done as a class with you as the facilitator, with small discussions in breakout groups, to then come back together to discuss more as a group. If your students are experienced in problem-based learning activities, you can have them do the entire problem in small groups.

Activity *(45 minutes per problem)*

You, as the facilitator, will guide your students in multiple discussions in order to come up with a solution to the problem presented. Be sure to use tips from the Introduction to Problem-Based Learning PDF.

After engaging in discussions, pose the following questions for students to discuss in small groups and then share out to the class:

- What human impacts on the environment did we see in the discussion(s) we just had? How does the increase in human use of natural resources impact wildlife? Do we see any of these same human impacts in our local area?
- What are some ways we can minimize human impact on our local environment? Discuss what methods could be used to monitor impacts as well as methods that could be used to decrease the impacts.

LESSON 4: SHAPES AND SIZES OF SCIENCE COMMUNICATION

OBJECTIVE

Students will learn the diversity of types of science communication and why it is important to effectively communicate science to the public. Students will practice communicating science in a format of their choice.

Materials

- Mural Artist Biography - Spel Uno*
- Exhibit Developer Video Interview *(30 minutes)*
- The Nat Blog Posts*

*See Appendix E

Preparation *(10 minutes)*

Distribute reference materials to students (digitally or physical copies). Test Exhibit Developer video on device for class viewing.

Activity *(1 hour 15 minutes, not including project)*

Revisiting 'What is Science Communication?':

Begin this lesson with an opening discussion revisiting your discussion from Pre-Visit Lesson 1. Show your students the class definition you wrote for science communication before you visited The Nat. Ask students the following questions in any order:

- Did your view of what science communication is and why it is important change after visiting the Museum? Is there anything you would like to add or take away from our original definition?
- On our visit to The Nat (particularly in the *Expedition Baja* exhibition), did you see any types of

science communication that were new to you? *(Possible answers may be: art/mural, exhibit text, exhibit models, interactives, and videos)*
- What type of science communication excites you the most?

Investigating Different Types of Science Communication:

- As a class, watch the interview of our Exhibit Developer to hear more about what goes into creating an exhibit, which is a form of science communication. Leave time after to discuss what stood out most to the students.
- In small groups or as a class, read the biography on Spel Uno and discuss the mural you saw on your visit to *Expedition Baja (see Appendix E for a photo of the mural).*
- Break students up into small groups and assign each group a different Nat blog post to read and discuss within their group. Use the following questions to help spur student discussions:
    - Who do you think the audience is for this post? Who was the author trying to reach?
    - What was the author trying to communicate to their audience?
    - Can you think of another way this message could have been communicated besides a blog post?
    - Why do you think you and your peer's perspectives are important? Is there an audience you could reach that the author of this blog post couldn't?
    - *Prep for Science Communication Project:* If you could teach others on a science topic, what would it be?

Science Communication Project:

The final part of this lesson is a Science Communication Project. Share with your students that they are tasked with teaching their peers about a science topic of their choice. Some examples to get their ideas flowing may include: what is your favorite endangered animal and how can people help them? How is climate change impacting a specific area/animal? Describe an interesting research study being done, or describe a unique science career path.

Students can use any form of scientific communication they would like (art, writing/blog post, infographic using Canva, video, exhibit design using poster board, etc.). The only requirement is that their project should be presented at the Gallery Walk, so if they are doing a video make sure they have a way to display it. **If a Gallery Walk will not work for your classroom setup, you can do individual presentations or another presentation type of your choice**

Gallery Walk: Once the student's projects are done, set up a gallery walk for them to view each other's work. For the gallery walk, projects will be displayed around the classroom. Half of the students will be standing next to their projects, while the other half walk around and view the other student's projects and ask any questions they have. After ~10-15 minutes, have the students swap roles. The gallery walk could also include students from other classrooms to come and view your students' projects.

APPENDIX A

CASE STUDY ACTIVITY: KEY WORD DEFINITIONS

Anthropogenic Impacts on Marine Subsidies to Coastal Ecosystems

Jeremy Long *(San Diego State University),* ***Rulon Clark*** *(San Diego State University),* ***Sarah Lester*** *(Florida State University),* ***Keith Lombardo*** *(National Park Service),* ***Jesús Sigala-Rodríguez*** *(Universidad Autónoma de Aguascalientes),* ***Ricardo DeSantiago*** *(San Diego State University),* ***Ana Sofia Gomez*** *(San Diego State University)*

COASTAL ECOSYSTEMS, LIKE ISLANDS, RECEIVE IMPORTANT NUTRIENTS FROM THE SEA.

PHOTO CREDIT: RICARDO DESANTIAGO

Key Takeaways

- Several coastal Baja California ecosystems receive important nutrient subsidies from the sea via seaweed wrack, carrion, and foraging seabirds.
- Some of the best studied global examples of marine subsidies to coastal food webs are the arid islands of Bahía de los Ángeles.
- Human activities, including climate change, invasive species introductions, and aquaculture, have the potential to modify the quantity and quality of these subsidies.
- Few studies have examined the anthropogenic impacts on marine subsidies, especially beyond the introduction of invasive predators to islands.

What is the focus and area of your research?

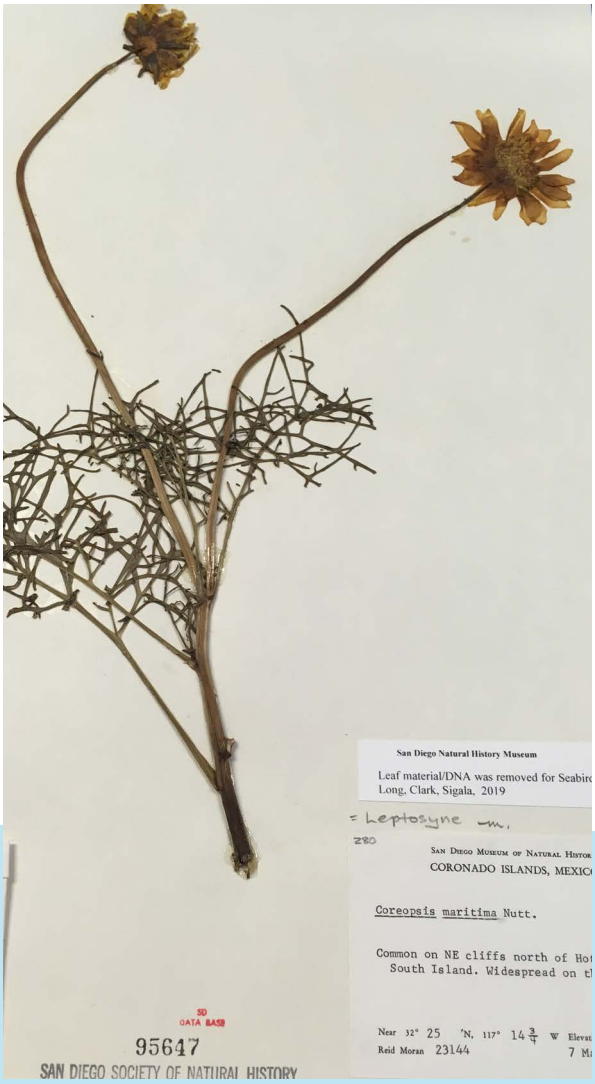
Marine subsidies (e.g. seabirds, seaweeds, fish, and marine mammal carcasses) move resources from the sea to islands. These subsidies can completely change coastal food webs. But, human activities threaten to change the quality and quantity of these subsidies. We seek to understand how humans are modifying these subsidies and the consequences of these modifications on recipient coastal zones.

How do you see climate change impacting the focus of your research?

Ecologists agree that climate change is the major stressor threatening natural habitats. Climate change can influence subsidies to coastal ecosystems via changed storm intensity and frequency, shifted distribution and abundance of marine populations, and altered precipitation patterns. For example, shifts between wet and dry years in the Gulf of California can shift the relative importance of seabird and seaweed-derived nutrients (*1*).

What are you most concerned about?

Our group has two major concerns regarding how climate change will affect marine subsidies to coastal ecosystems. First, previous research suggests that abiotic factors (e.g. precipitation) susceptible to climate change dramatically influence the role of subsidies. Second, climate change is likely to modify the quantity (e.g. amount of baitfish) and quality (e.g. species composition) of marine species which could, in turn, influence the impact of how these species are used as subsidies.



PLANTS FROM SEABIRD-SUBSIDIZED ISLANDS HAVE ISOTOPIC SIGNATURES UNIQUE FROM POPULATIONS THAT DON'T RECEIVE THESE SUBSIDIES. WE ARE USING STABLE ISOTOPES TO EXPLORE IF THE ROLE OF MARINE SUBSIDIES TO THESE ISLANDS HAVE CHANGED OVER TIME.

CREDIT: ANA SOFIA GOMEZ

What are the gaps in understanding that need more research?

First, we need to understand the current role of subsidies to coastal ecosystems beyond Bahía de los Ángeles and around Baja California. Second, we need to model how climate change will impact the quantity and quality of subsidies these ecosystems will receive. Third, we need experiments that explore how such changes will impact recipient ecosystems. And fourth, we need to develop and implement standardized protocols that monitor marine subsidies to coastal ecosystems.

PELICANS, SEAGULLS, AND OTHER BIRDS BRING NUTRIENTS FROM THE SEA TO THE COAST ESPECIALLY IN NESTING AREAS.

CREDIT: RICARDO DESANTIAGO

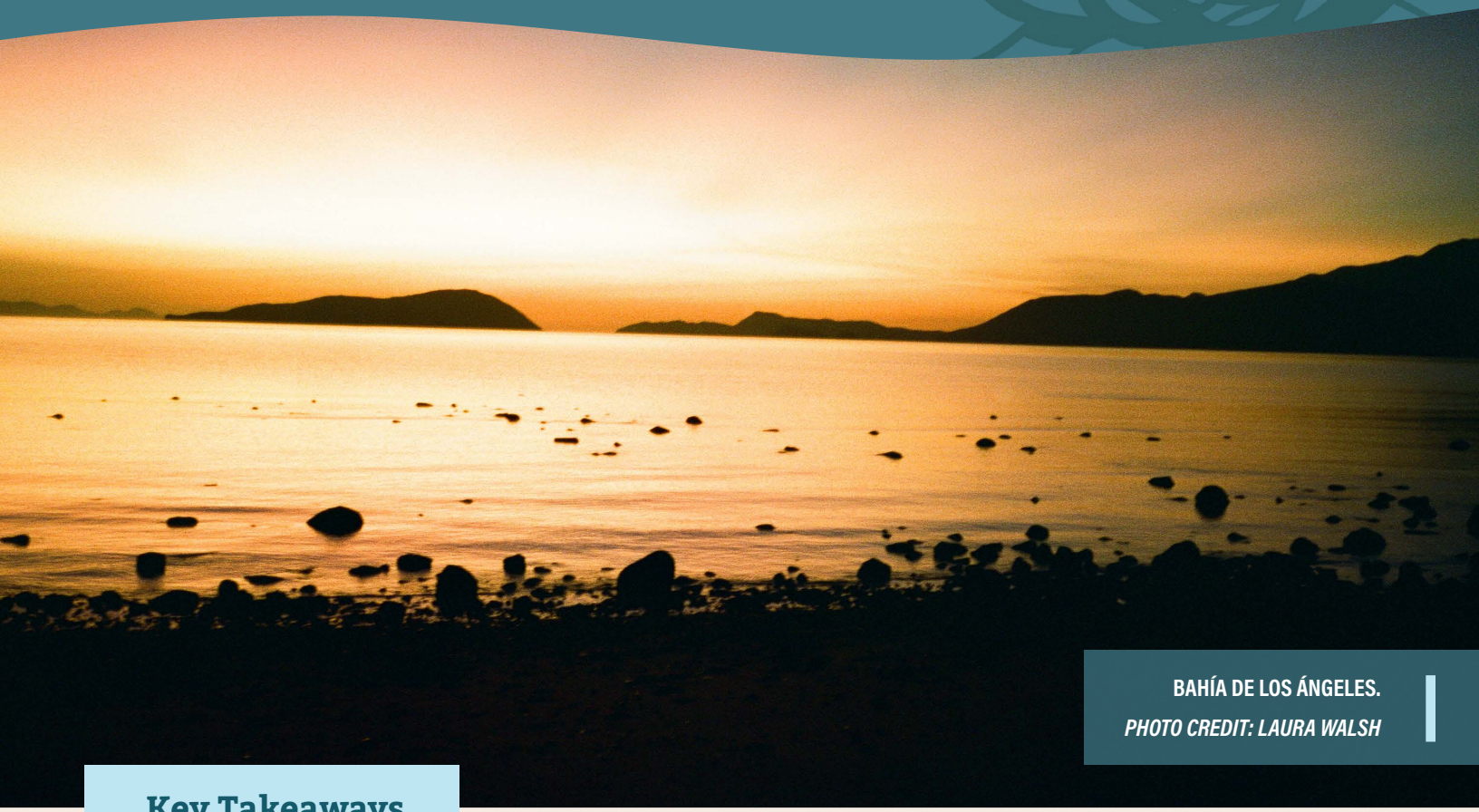
References

1. Stapp, P., Polis, G. A., & Sánchez Piñero, F. (1999). Stable isotopes reveal strong marine and El Niño effects on island food webs. *Nature, 401*(6752), 467–469. https://doi.org/10.1038/46769

BAJA WORKING GROUP - CLIMATE SCIENCE ALLIANCE

Identifying Opportunities and Challenges for Protecting Against Extreme Heat in Southern California-Baja California Border Communities

Kristin VanderMolen (Desert Research Institute)
Benjamin Hatchett (Desert Research Institute)



BAHÍA DE LOS ÁNGELES.
PHOTO CREDIT: LAURA WALSH

Key Takeaways

- Southern and Baja California experience extreme heat throughout the spring and summer seasons with historic warming trends projected to continue through the 21st century.
- Many individuals and communities lack access to the information, resources, and opportunities needed to be able to protect against extreme heat.
- Evaluation of existing and emergent heat protection policies, programs, and infrastructure will be important for improving understanding of their effectiveness and for informing similar efforts in the future.

What is the focus and area of your research?

The focus of our work is to understand the opportunities and challenges that lead to individual and community action/non-action in protecting against extreme heat in Southern California-Baja California border communities, one of the hottest regions in North America. To accomplish this task, we are engaging with public health, nonprofit, and community-based organizations as well as individuals in particularly at-risk communities to understand what information, resources, and opportunities exist and/or are needed to support protective action. A primary output will be a series of recommendations and next steps generated in collaboration with those organizations for fostering the opportunities and addressing the challenges identified.

How do you see climate change impacting the focus of your work?

There are many ways in which climate change impacts the focus of this work. One example relates to the high levels of employment in outdoor occupations within the communities of study, including in agriculture, construction, and tourism. Indoor occupations, such as manufacturing and logistics, are also at risk for extreme heat exposure. The actual rates of heat-related illness (HRI) are probably higher than estimated for these occupational groups, as HRI is often under-recognized and under-reported. However, researchers have estimated that agricultural workers, for example, are at least four times more likely than non-agricultural workers to suffer from HRI. The risk of HRI for agricultural workers and other occupational groups exposed to extreme heat is expected to increase over time as the frequency, magnitude, and duration of heat events increase.

PHOTO CREDIT: TIM MOSSHOLDER

What climate impacts are you seeing in your focus area?

Historic warming trends in both minimum and maximum temperatures have been identified in Southern and Baja California. Climate projections indicate these trends will continue through the 21st century, though the magnitudes of regional warming depend on greenhouse gas emissions (higher emissions produce more warming). While projections of precipitation vary in sign and magnitude for both winter and monsoon seasons, increased evaporative demand will result in a net decline in water availability for domestic uses such as drinking water and irrigation. Marine heatwaves, such as occurred during 2014-2016, are also expected to intensify in a warming climate. These events negatively impact ocean ecosystems and local economies dependent on fisheries. In cities, the built environment limits radiational cooling at night, leading to an urban heat island effect that maintains higher nighttime temperatures and reduces a person's ability to recover from heat stress. The urban heat island effect also creates a greater demand for energy for cooling. The compounding effects of background warming, urban warming, and the increased frequency and duration of extreme heat events will create numerous challenges for public health and energy infrastructure.

What are you most concerned about?

It is critical that people have access to the information, resources, and opportunities necessary to protect against extreme heat, particularly as the frequency, magnitude, and duration of heat events increase. This includes access to education about HRI and regulatory standards, affordable air conditioning and healthcare, and opportunities to influence decisions made about local communities that shape health outcomes. Researchers can assist efforts to ensure that people have such access but ultimately it requires collective will and action.

PHOTO CREDIT: SAMEERAH MUNSHI

What are the gaps in understanding that need more research?

Increasingly, heat protection policies, programs, and infrastructure (e.g., regulatory standards, heat warning messaging, cooling centers) are emerging to enable and support individual and community protective action. Formal evaluation of those efforts will be important for improving understanding of their effectiveness and for informing similar efforts in the future. Additionally, data availability limits assessments of long-term trends in environmental variables including temperature and humidity as well as confounding stressors such as air pollution. Increased environmental monitoring is critical to observe trends and to accurately assess impacts of extreme events.

What is your plan moving forward to start to better understand or minimize the impacts from climate change?

Currently we are working with county government, nonprofit, and community-based organizations to create educational opportunities for people to learn about HRI and regulatory standards and to explore new mechanisms for ensuring that at-risk communities receive timely information about excessive heat watches and warnings. However, structural barriers both to individual and community protection will need to be overcome if climate equity, as it relates to extreme heat, is to be achieved. We are also evaluating climate projections to better understand changes in extreme heat events at regional scales to guide adaptation strategies.

PHOTO CREDIT: BARBARA ZANDOVAL

From Soil to Sky: Monitoring Mangroves in a Changing Climate

Paula Ezcurra *(Climate Science Alliance)*
Astrid Hsu *(Scripps Institution of Oceanography)*
Paula Sternberg Rodríguez *(Centro de Investigaciones Biológicas del Noroeste)*

PHOTO CREDIT: DIEGO GAMERO

Key Takeaways

- We seek to study the best way to assess the ecological value and monitor the health of mangrove ecosystems which provide numerous ecosystem services in an effort to improve conservation efforts in the face of climate change.
- There remains much uncertainty around the capacity of mangroves to adapt to a changing climate, as well as how these changing conditions will affect the ecosystem services they provide.
- Implementing and improving monitoring methods for mangrove ecosystems in Baja California can support answering emerging questions about mangroves' resilience and capacity to mitigate and adapt to a changing climate.

What is the focus and area of your research?

Our focus is on mangrove ecosystems in Baja California Sur, primarily those in the La Paz Bay, on the Gulf side of the Peninsula, and those of Magdalena Bay, on the Pacific coast. Specifically, we seek to study how best to assess the ecological value and monitor the health of these ecosystems which provide numerous ecosystem services, in an effort to improve conservation endeavours. Our monitoring and valuing efforts are primarily carried out through remote sensing with drones, on-the-ground surveys, and belowground carbon measurements—a unique soil-to-sky approach.

What do you anticipate being impacts on your focus area?

Mangroves are well-adapted to handle tidal fluctuations and rising seas. Evidence suggests that mangroves have long adapted to rising sea levels via vertical accretion (*1*). However, as rates of sea level rise increase in response to the effects of climate change, the ability of mangroves to adapt may become limited—specifically those mangrove forests that are not capable of retreating further inland due to urban or topographic constraints. On the other hand, rising air temperatures may actually increase the availability of suitable mangrove habitat at higher latitudes (*2*).

What are you most concerned about?

Mangrove forests are becoming increasingly valued for the ecosystem services that they provide to natural and human communities [e.g., (*3*–*5*)], including their climate change mitigation potential (*6*). However, there remains much uncertainty around the capacity of mangroves to adapt to a changing climate, and how these changing conditions will affect the ecosystem services they provide.

In addition to the impacts of climate change, mangrove forest health and the myriad of related ecosystem services also face threats from non-climatic factors such as fragmentation and pollution. This combination of threats further endangers the overall ecosystem health of these species. By focusing on holistic approaches to managing and monitoring climate and non-climate stressors, we can identify solutions that increase the resilience of mangroves across Baja California Sur.

PHOTO CREDIT: ASTRID HSU

What are the gaps in understanding that need more research?

We suggest that areas for future research include surveying the post-storm recovery of mangroves. As storm events become a larger threat due to anthropogenic climate change, the ability of mangroves to serve as barriers will become even more important. But, how mangroves recover between storm events and their capacity to withstand multiple storms is not well studied. Additionally, as sea level rise continues to threaten coastal ecosystems, downscaled regional models for the Baja California Sur region will become critical to understanding where the largest threats exist.

What is your plan moving forward to start to better understand or minimize the impacts from climate change?

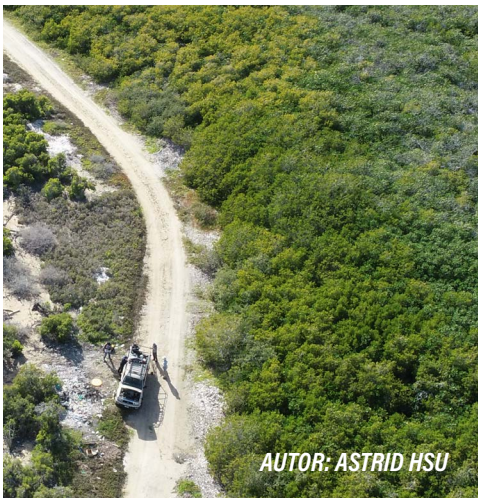
We work to implement, increase, and improve various monitoring methods for mangrove ecosystems in Baja California to ensure that we can answer emerging questions about their capacity to mitigate climate change through carbon sequestration and their ability to adapt to a changing environment.

First, we are working with researchers and resource managers to harness the power of remote sensing. The complimentary use of satellite and drone imagery provides the means to monitor mangrove forests at varying resolutions and frequencies, up to image resolutions of 3 cm/pixel and daily imagery. Remote sensing tools enable end-users to collect a wide variety of data on mangroves, such as extent, forest biomass estimates, species delineation, and forest carbon flux (*7*). Combining on-the-ground methods with aerial tools can increase mangrove forest monitoring frequency, allowing conservation practices and priorities to better reflect current conditions.

Second, we are comparing different methods for measuring belowground carbon in mangrove ecosystems, with the goal of developing a conversion system for each method. This way, the methods used to determine underground carbon storage capacity among different mangrove forests can be compared more easily, which can help managers prioritize different mangrove stands based on their capacity for carbon storage.

PHOTO CREDIT: PAULA STERNBERG RODRÍGUEZ

And lastly, building local capacity for emerging technology—such as drones—is critical for the establishment of local mangrove monitoring. This requires training community members in the necessary technical skills, investing in digital infrastructure, and garnering support from the international community, something we have already begun to undertake (*8*). Our promotion of regional remote-sensing expertise will give local resource managers and community members the technical foundation necessary to acquire and integrate the most up-to-date mangrove-health data into climate mitigation and adaptation plans.


AUTOR: ASTRID HSU

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Monitoring Ecological Dynamics and Climate Change Impacts in the Rocky Intertidal of the Californias

Keith Lombardo *(Southern California Research Learning Center, National Park Service)*
Ricardo Domínguez *(Terra Peninsular)*

A SINGULAR BOLT INDICATES THE LOCATION OF A LONG-TERM OWL LIMPET MONITORING SITE WHERE A TEAM OF BIOLOGISTS COLLECT ROCKY INTERTIDAL DATA AT CABRILLO NATIONAL MONUMENT IN SAN DIEGO, CALIFORNIA.

PHOTO CREDIT: MICHAEL READY PHOTOGRAPHY

Key Takeaways

- Long-term monitoring allows land managers to track ecological changes that are both naturally and anthropogenically driven.
- Rocky intertidal organisms are susceptible to climate change impacts such as ocean acidification and increased seawater temperatures.
- International collaboration enhances our scientific understanding.

What is the focus and area of your research?

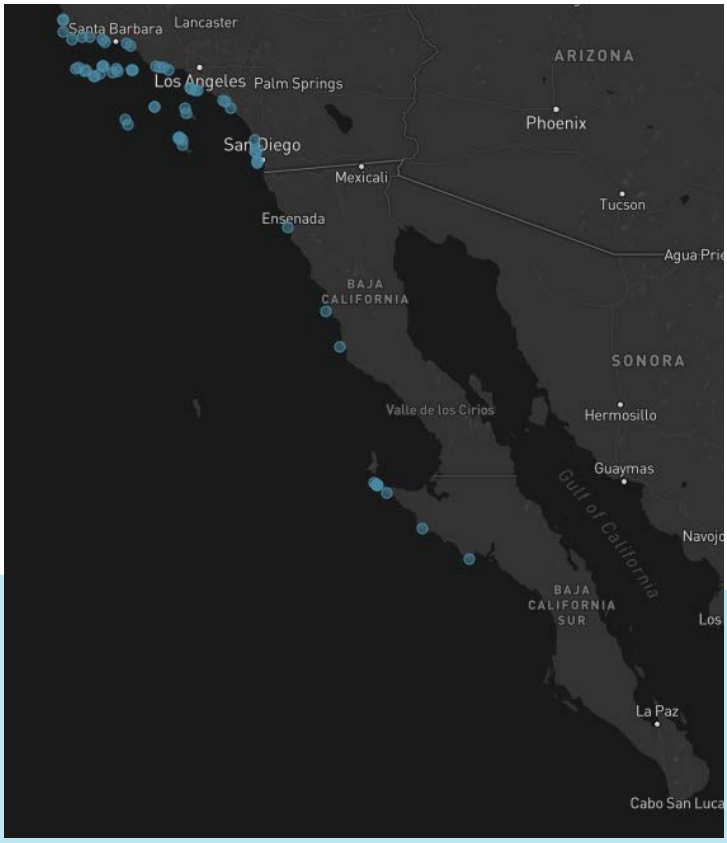
The focus of our work is to document biotic and abiotic changes in the rocky intertidal habitats in the Californias. The data we collect is part of a **broad network of monitoring sites**, that stretches from San Quintín, Baja California to southwestern Alaska. Employing identical methodologies across all sites and targeting similar suites of species allows for comparison of trends across vast geographic regions, which can help managers differentiate local drivers of change against regional or global scale influences.

How do you see climate change impacting the focus of your research?

Thus far, the research community has identified ocean acidification and increased ocean temperatures as the two greatest threats to rocky intertidal ecosystems. Ocean acidification directly impacts many marine invertebrates by increasing calcium carbonate solubility, thus inhibiting the formation and maintenance of shells and exoskeletons in a vast number of intertidal organisms, some of which are highly prized in marine aquaculture and serve as keystone ecological species. Increased seawater temperatures have been linked to disease outbreaks such as sea star wasting disease, which has decimated sea star populations throughout the west coast of North America.

What future impacts to natural resources do you anticipate?

Negative impacts upon keystone species can have a profound impact on natural systems, as exhibited by the loss of black abalone (*Haliotis cracherodii*) from a vast majority of intertidal habitats. Ocean acidification has the potential to further alter intertidal systems and push them into novel and unstable states.



DISTRIBUTION OF MARINe (MULTI-AGENCY ROCKY INTERTIDAL NETWORK) LONG-TERM MONITORING SITES IN SOUTHERN CALIFORNIA AND THE BAJA PENINSULA.

MARINe: https://marine.ucsc.edu

What are you most concerned about?

Long-term monitoring data are critical to understanding natural oscillations and changes that are a result of anthropogenic drivers. It can provide significant temporal and spatial context to short-term research projects. However, long-term monitoring requires commitment and patience as it typically can take decades for trends to emerge within the data. Many institutions don't have the financial flexibility to undertake such efforts and thus we are often limited in our ability to apply scientific results to land management actions.

What are the gaps in understanding that need more research?

While the installation of the first two rocky intertidal monitoring sites in Baja California is a great accomplishment, there is a significant amount of intertidal habitat between San Quintín and San Diego that is currently not monitored. Additional sites would provide greater connectivity and enhance our understanding of intertidal habitats in Baja California. Additionally, more work is needed to better understand the impacts of ocean acidification on intertidal organisms and habitats. Most ocean acidification research is focused on subtidal and deep-water marine environments; thus, we don't have a full understanding of the impacts within the intertidal.

What is your plan moving forward to start to better understand or minimize the impacts from climate change?

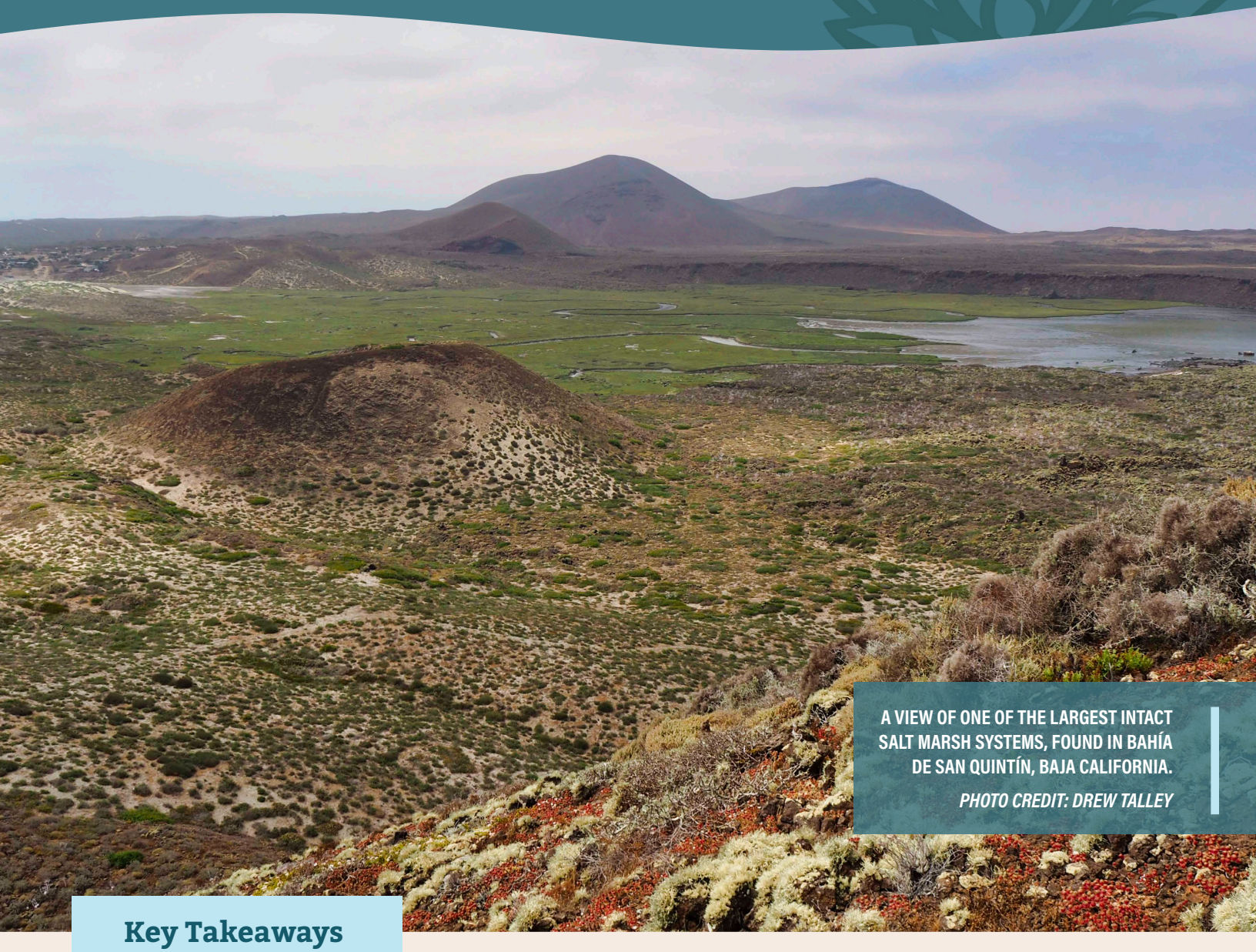
Climate change is a global issue and requires a global response. Expanding our data collection efforts into areas that lack study is one small way we can contribute. Furthermore, collaborative efforts by managers and scientists in the Californias builds a platform for international partnerships which will be required if we are to tackle the enormous issue of climate change.

INTERTIDAL BIOLOGISTS FROM TERRA PENINSULAR AND THE NATIONAL PARK SERVICE COLLABORATE TO COLLECT DATA ON VARIOUS TARGET SPECIES (SUCH AS THE GIANT OWL LIMPET, *Lottia gigantea*, PICTURED HERE) AT SCRIPPS COASTAL RESERVE, LA JOLLA, CALIFORNIA.

PHOTO CREDIT: MICHAEL READY PHOTOGRAPHY

Baja California Wetlands

Drew Talley *(University of San Diego)*



A VIEW OF ONE OF THE LARGEST INTACT SALT MARSH SYSTEMS, FOUND IN BAHÍA DE SAN QUINTÍN, BAJA CALIFORNIA.

PHOTO CREDIT: DREW TALLEY

Key Takeaways

- Sea level rise and warming temperatures threaten salt marshes in the Californias.
- Establishing long-term monitoring and leveraging historical research will allow us to better predict and manage climate change impacts.

What is the focus of your research?

With numerous collaborators over the last 25 years, including the Ensenada Center for Scientific Research and Higher Education, Terra Peninsular, California State University at Long Beach, and Scripps Institution of Oceanography, I have examined the food webs of salt marshes in the Californias, from San Francisco Bay to Bahía de San Quintín and the upper Gulf of California. A major focus of our work has been understanding habitat connectivity (in particular, but not limited to, spatial subsidy), and how human impacts can act to disrupt natural levels of connectivity.

How do you see climate change impacting the focus of your research?

Probably the most pressing issues outside of direct human activities (e.g., habitat loss and destruction) are sea level rise (SLR) and warming temperatures. With so many wetlands already lost, and those that remain often constrained at the upland margin by man-made structures, wetlands have little room to migrate with SLR. Further, warming temperatures can lead to a shift in the community from temperate species to more tropical ones.

What climate impacts are you seeing?

We are already seeing taxa with southern affinities becoming more common in our wetlands, and that trend will undoubtedly continue, with warmer-water species becoming permanently established following El Niño events. Further, SLR is creating erosion of barrier beaches protecting some wetlands, and generally converting wetlands to more deep-water habitat.

What are you most concerned about?

As mentioned by other Baja Working Group scientists, long-term monitoring is critical for teasing apart natural from anthropogenic changes to natural systems. Yet this sort of work can be difficult to fund, and suffers a misperception in some academic circles that it is “not real research.”

THE CALIFORNIA KILLIFISH, *FUNDULUS PARVIPINNIS* - A NATIVE FISH THAT IS AN IMPORTANT FOOD WEB LINKAGE IN WETLANDS OF THE CALIFORNIAS.

PHOTO CREDIT: DREW TALLEY

What are the gaps in understanding that need more research?

Wetlands are often viewed in isolation of their landscape and component habitats. Understanding the reticulate interconnections among and across habitats (e.g., seagrass beds, unvegetated flats, upland habitats) is critical for understanding, managing, and restoring wetlands. Even basic natural history of many wetland inhabitants are sorely lacking.

What is your plan moving forward to start to better understand or minimize the impacts from climate change?

Critical to protecting these coastal transition zones is better understanding the natural dynamics, and engaging stakeholders (public, managers, industry) that use and affect these habitats. Revisiting previous studies [e.g., (*1–3*)] while engaging the public in monitoring programs is a powerful first step towards improving our understanding and our ability to predict future climate impacts.

Establishing standardized monitoring programs is critical to these efforts. We should also work to leverage existing historical research, much of which is buried in "grey literature" such as graduate student theses and government reports. Re-surveying these historical studies can provide some insight into long-term changes in these threatened ecosystems.

***ABRONIA MARÍTIMA* EN LAS DUNAS DEL SOCORRO EN BAHÍA DE SAN QUINTÍN, BAJA CALIFORNIA.**

AUTOR: DREW TALLEY

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Climate Change Mitigation and Adaptation Actions in the Sierra de San Pedro Mártir

Pamela Castro Figueroa *(Terra Peninsular)*
Mariana Elizabeth Espinosa Blas *(Terra Peninsular)*

Key Takeaways:

- Increasing wildfires emit carbon dioxide (CO_2) into the atmosphere and reduce the capacity of forest floors and forest biomass to capture and store CO_2, putting the community and the ecosystem services that the Sierra provides at risk.
- It is important to focus efforts on understanding the effects of fires on soil (specifically, their quality and carbon storage capacity), the spatiotemporal viability of prescribed burns in the areas, their effects on water balances, and their effects on the distribution of flora and fauna in the region.

What is the focus and area of your research?

The Sierra de San Pedro Mártir, located in the central part of Baja California, is part of the Mediterranean bioclimatic corridor and of the extreme southern portion of the California Floristic Province—one of the 35 global biodiversity hotspots. Since 1947, parts of the highest and most forested areas of the Sierra were decreed part of a National Park, a category of Federal Natural Protected Area, for their conservation. Similarly, the Sierra de San Pedro Mártir is recognized as a Priority Terrestrial Region (No. 10 - CONABIO), Priority Hydrological Region (No.1 - CONABIO), and an Area of Importance for Bird Conservation (No. 104). This is an area recognized for its pristine ecosystems, such as chaparral, meadow-wetlands, and mixed forests, where diverse species of flora and fauna are housed. It is also an area where diverse ecosystem services are provided, including its hydrological value, which communities such as San Quintín, Lázaro Cárdenas, and Vicente Guerrero rely on.

Despite being considered an area with a high degree of conservation measures, in reality the region faces a variety of threats, including forest fires and overgrazing.

How do you see climate change impacting the focus of your work?

Climate change will impact the focus of our work through the projected scenarios of increasing temperatures and decreasing rainfall events in the region. Changes in these patterns have a direct effect on the frequency and severity of forest fires (*1*).

The suppression of fire over recent years has helped fuel loads accumulate into large quantities, increasing the risk of fires.

As a climate change adaptation measure, we have worked to contribute to a healthy fire regime, through fire management actions focused on the reduction of accumulated combustibles and on the restoration of firebreak gaps. Similarly, in an attempt to contribute to biomass carbon capture, we worked on reforesting 10 hectares in the Sierra and on activities that support soil conservation.

What do you anticipate being impacts on your focus area?

According to climate change projections, it is estimated that, in the region, there will be changes in precipitation and temperature patterns (*1*).

The decrease in precipitation events and the increase in temperature means more prolonged dry seasons and, as a consequence, a heightened risk of more frequent and severe forest fires in the region. That, in turn, modifies natural fire regimes and the resilience capacity of the ecosystems (*2*).

Moreover, another projected effect of climate change for the Sierra is the decrease in the abundance and distribution of coniferous species (*3*). In addition to placing the region at a high level of vulnerability to the impacts of climate change, this also endangers the ecosystem services that the Sierra provides to communities—such as those associated with hydrological aspects and refuge zones for endemic species.

What are you most concerned about?

While fire in Mediterranean ecosystems is fundamental to ecological processes, an increase in forest fire frequency and severity is also harmful, because as natural fire regimes are modified, an area's capacity for resilience is affected.

An increase in forest fires releases carbon dioxide (CO_2) from forest soils and biomass, putting at risk the ecosystem services that the Sierra provides to communities.

Another important factor is the capacity to respond directly and indirectly to fires. In many places, the trained and equipped personnel available is less than the effort needed and the amount of ground that the response effort must cover.

What are the gaps in understanding that need more research?

Currently, there exist Integrated Fire Management and Climate Change Adaptation Programs for the 1857 and Sierra de San Pedro Mártir National Parks complex (*1, 2*), where the importance of fire in Mediterranean ecosystems and projections of climate change impacts are described, as well as direct and indirect actions to lessen risks and vulnerabilities.

It is important to channel efforts to understand the effects of fires on soils (specifically, their quality and carbon storage capacity), the spatiotemporal viability of prescribed burns in the region, the effects on hydrological balance, and on the distribution of species of flora and fauna in the region.

Lastly, it is important to boost the preparedness of front-line-response and wildfire-fighting personnel, in addition to spreading information and awareness for the community about the importance of the Sierra and about fire ecology in the region.

What is your plan moving forward to start to better understand or minimize the impacts from climate change?

Previously, various climate change adaptation measures were implemented within the San Pedro Mártir National Park and its area of influence, with the goal of contributing to the conservation and protection of forest floors, ecosystem restoration, long-term capture of carbon dioxide in forest biomass (planned reforestation), and management of a healthy fire regime.

For the management of a healthy fire regime, the focus was on the reduction of accumulated combustibles through the pruning of dead trees and cutting of trunks that represent a propagation and combustion risk during a fire. Another focus was the rehabilitation of firebreak gaps.

In this respect, we seek to extend the implementation of climate change adaptation measures, and to continue working on forest floor conservation alongside the cattle-raising community in improving and managing their production activities. We also seek to carry out awareness-raising actions with the community about the effects of climate change in our region and the ecosystem services that will be affected.

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Coastal Ecosystems

- **Ecosystem** - a system, or a group of interconnected elements, formed by the interaction of a community of organisms with their environment
- **Marine subsidies** - carcasses of marine animals
- **Food web** - a diagram that shows the transfer of energy through multiple different organisms in an area; they are made of multiple food chains
- **Anthropogenic** - something that is made or caused by humans
- **Abiotic factors** - refers to all the non-living factors present in an ecosystem (ex. sunlight, water, land)
- **Climate change** - describes a change in the average conditions — such as temperature and rainfall — in a region over a long period of time

Extreme Heat

- **Evaluation** - to determine the significance, worth, or condition of by careful study
- **Infrastructure** - the basic facilities and services needed for a community to function, such as transportation and communications systems, water and power lines, and public institutions
- **Climate change** - describes a change in the average conditions, such as temperature and rainfall, in a region over a long period of time
- **Frequency** - the rate at which something occurs or is repeated over a particular period of time or in a given sample
- **Magnitude** - the great size or extent of something
- **Duration** - the time during which something continues

Wetlands

- **Salt marsh** - coastal wetlands that are flooded and drained by salt water brought in by the tides
- **Climate change** - describes a change in the average conditions, such as temperature and rainfall, in a region over a long period of time
- **Food web** - A food web consists of all the food chains in a single ecosystem. Each living thing in an ecosystem is part of multiple food chains. Each food chain is one possible path that energy and nutrients may take as they move through the ecosystem.
- **Spatial subsidy** - the movement of nutrients or energy between ecosystem
- **Affinity** - a natural liking to something
- **Anthropogenic** - something that is made or caused by humans
- **Reticulate interconnections** – net or network-like connections
- **Standardize** – to conform to a standard or guideline

Texts for older students or ones that need more of a challenge:

Wildfires

- **Climate change** - describes a change in the average conditions, such as temperature and rainfall, in a region over a long period of time
- **Mitigation** - the action of reducing the severity, seriousness, or painfulness of something
- **Biomass** - the total mass of organisms in a given area
- **Ecosystem services** - all the varied benefits and services that are provided to humans by the natural environment or ecosystem
- **Spatiotemporal viability** - the space and time at which something will work successfully
- **Biodiversity hotspot** - areas that are rich in biodiversity (the variety of life in the world or in a particular habitat or ecosystem) AND highly threatened by human activities
- **Ecosystem** - a system, or a group of interconnected elements, formed by the interaction of a community of organisms with their environment
- **Hydrological** - relating to the properties of the earth's water, and especially its movement in relation to land
- **Ecological processes** - the ways in which organisms interact, and the processes that determine the cycling of energy and nutrients through natural systems

Monitoring Mangroves

- **Assess** – to evaluate or estimate the nature, ability, or quality of
- **Ecological value** - the level of benefits that all factors that make up natural ecosystems provide to support native life forms
- **Mangrove** - a group of trees and shrubs that live in the coastal intertidal zone
- **Ecosystem services** - all the varied benefits and services that are provided to humans by the natural environment or ecosystem
- **Climate change** - describes a change in the average conditions, such as temperature and rainfall, in a region over a long period of time
- **Mitigate** - to make less severe or serious
- **Vertical accretion** - when rivers grow during periodic flooding and leave sediment on top of the surface they expand to during the flooding
- **Fragmentation** - when a large area of natural space is broken up into smaller, less connected patches
- **Pollution** - the contamination of air, water, or soil by substances that are harmful to living organisms
- **Anthropogenic** - something that is made or caused by humans
- **Carbon sequestration** - a natural or artificial process by which carbon dioxide is removed from the atmosphere and held in solid or liquid form

Rocky Intertidal Zone

- **Ecological dynamics** - how ecological systems undergo change
- **Climate change** - describes a change in the average conditions, such as temperature and rainfall, in a region over a long period of time
- **Rocky intertidal ecosystems** - the rocky shores that lie at the edge of the ocean, between the high and low tides
- **Anthropogenic** - something that is made or caused by humans
- **Ocean acidification** - a change in the properties of ocean water where it becomes more acidic, which can be harmful for plants and animals
- **Biotic** - something related to living things
- **Abiotic** - something related to non-living things
- **Methodology** - a system of methods used in a particular area of study
- **Keystone species** - a species on which other species in an ecosystem largely depend, such that if it were removed the ecosystem would change drastically
- **Temporal** - relating to time
- **Spatial** - relating to or occupying space

ANNOTATING TEXT GUIDE

• # the paragraphs for quick reference during discussions
• Underline topic sentences/main ideas
• Highlight science terms → Define in the margins
• Circle confusing words/phrases → In the margins, write question to ask peers
• When something in the text connects with you or your community, write in the margins what that connection is.
• In 3-4 sentences or bullet points at the end, summarize the research taking place and why it is important.

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APPENDIX B

SAVING THE CALIFORNIA RED-LEGGED FROG LAB SHEET

the nat | SAN DIEGO NATURAL HISTORY MUSEUM

Herpetologist:_____

Saving the California Red-legged Frog Lab Sheet

Background Information:

With a collaborative spirit and great teamwork, The Nat is contributing to the recovery of the California red-legged frog (*Rana draytonii*) in both the US and Mexico. The California red-legged frog (CRLF) is the largest native frog in southern California and Baja California, Mexico. The species was once found from central California through Baja California at different elevations, from sea level to 5000 feet.

Freshwater ecosystems such as rivers, creeks, and lakes in this region face immense pressures from human activities like agricultural pollution, development pressures, and more. As a result, many species that depend on freshwater habitats have been driven to near extinction, with 95% of our wetlands having been eliminated. Within the remaining wetlands, the CRLF plays an important role in the ecological community as both predator and prey in streams, creeks, and ponds.

In San Diego County, the CRLF went extinct in the 1970's due to many human impacts. However, our team's reintroduction efforts have brought them back! The Baja California populations also suffered major declines as a result of the same pressures.

The first priority for the CRLF recovery team was to see how the remaining 10 populations in Baja California were doing and to help them increase their numbers. In addition to regular monitoring, the team dug deep water ponds to provide suitable breeding habitats that will hold water during droughts. Our reintroduction efforts that moved frog eggs from Mexico to southern California established populations across a wider geographic range, reducing the risk of a single unpredictable event such as wildfire from destroying all the populations in one fell swoop.

Current Situation:

The herpetology team is looking to improve their translocation efforts by accurately predicting when the red-legged frogs will lay their eggs. Before eggs are laid, males call to attract females. Your task, as our newest herpetologists, is to see if there is a connection between frog calls and seasonal weather patterns in the environment.

Herpetologist:_____

Section 1: Acoustic Monitoring

In December 2020, remote sensors were installed and programmed to automatically record frog calls every night for the winter. The recorders captured audio both above and under water, which is helpful for recording the relatively quiet call of California Red Legged Frog. Males call with their head above water and their body submerged, they amplify the sound of their call using dual (yes two!) vocal sacs. Programmed to record at regular intervals for short periods of time, the acoustic recorders are obtaining a snapshot of the calling frogs.

Task 1:

1. Listen to the audio file labeled *Rana draytonii* to learn the call of the CA red-legged frog. Describe the call, does it remind you of anything else you have heard? (ex. loud, quiet, low-pitched, high-pitched, bark, grunt, whistle)

2. Next, listen to the audio file labeled *Pseudacris regilla* to learn the call of the Pacific chorus frog, which is also found in the same habitat as the red-legged frog. Describe what their call sounds like. (*Make sure to listen to the different calls multiple times and note the distinct differences between the two*)

Herpetologist:_____

Task 2: Listen to the 5 audio files labeled by date. In the table below, mark whether or not the sound of the red-legged frog (*Rana draytonii*) can be heard in each acoustic clip. Then with your research team, write the total # of yes' for each date and graph your accumulated data on the axis provided (Date is on the x-axis, # of RLF Call Occurrences on the y-axis).

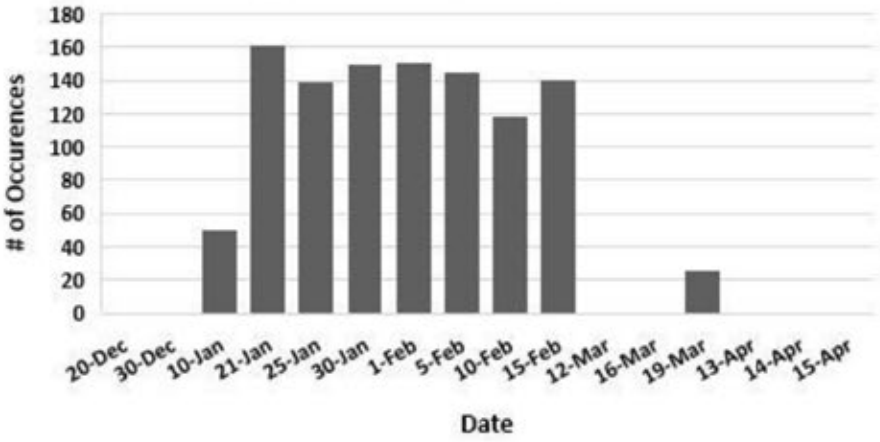
Date	RLF Call Present? (Y/N)	Total Yes' for Team (# of RLF Call Occurrences)
Jan 15		
Jan 25		
Feb 10		
Feb 20		
Mar 05		

Herpetologist: _____

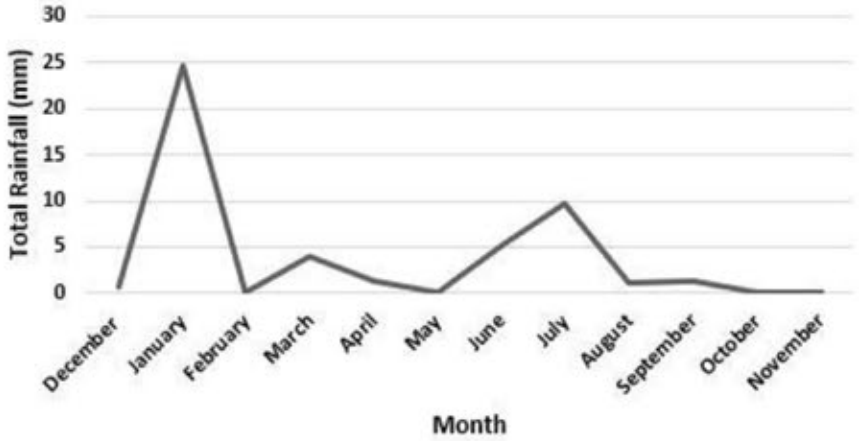
Section 2: Analyzing Frog Call Data

Using data from the graphs below, answer questions 1 – 5 with your research team.

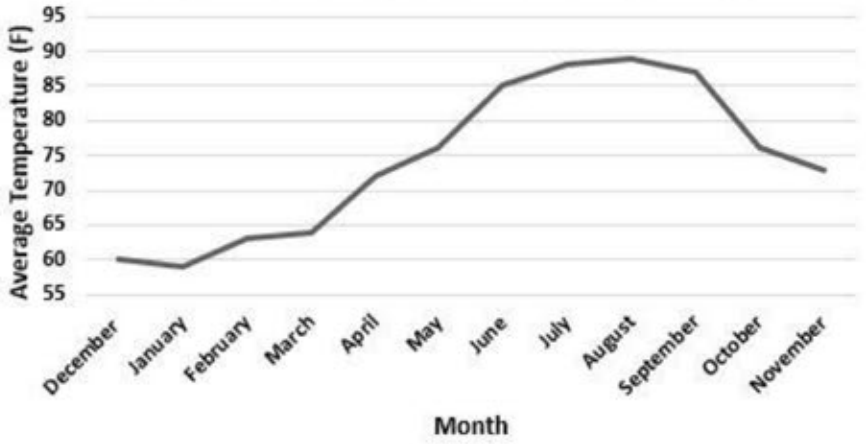
Graph 1: Red-legged Frog Calls



Graph 2: Precipitation (Dec 2020 - Nov 2021)



Graph 3: Temperature (Dec 2020 - Nov 2021)



Herpetologist:_____

Sentence Frame Bank: These sentence frames can be used to help answer the questions below.

Based on the data shown in Graph 1, the red-legged frog calls the most in _____.

Based on the data shown in Graph 2, the most precipitation occurs in _____.

Based on the data shown in Graph 3, the _____ temperature occurs in _____.

When total rainfall is _____, there are _____ RLF calls.

When temperatures are _____, there are _____ RLF calls.

I notice that the greatest number of RLF calls happens when _____ is _____.

Questions

1. Using Graph 1, during what month(s) do the red-legged frogs call the most?

2. Using Graph 2, during what month(s) does the most precipitation occur in the region?

3. Using Graph 3, during what month does the highest temperature occur? What about the lowest temperature?

Herpetologist: _____

4. Referencing the graphs or your answers from Q1-Q3, does a change in precipitation or temperature correlate with an increase in RLF calls?

5. Our researchers have found that red-legged frogs only call during this time of year. Make a prediction for why this might be.

Herpetologist:_____

Section 3: Recommendations for Conservation Efforts

Discuss with your research team to come up with answers to questions 1 – 4.

1. Remember that males call to attract females just before egg masses are laid. When planning for egg translocation efforts, how would the pattern you observed in Section 2 help in deciding when to search for egg masses?

2. How might climate change impact the time of year that red-legged frogs lay their egg masses? *(Hint: climate change causes changes in temperature and a shift in weather patterns like precipitation over time)*

Herpetologist:_____

3. Red-legged frogs are found at different elevations. The data above was collected from one site *(at 2000 feet above sea level).* Do you think this data would be the same for red-legged frogs at other elevations? Why or why not?

4. Our herpetologists noticed that cattle frequently come to ponds to drink water, often submerging their whole bodies in the water. This presents a conflict between agriculture and conservation efforts. Using the data above, what solution would you pose to resolve this conflict?

APPENDIX C

EXPLORING ISLAND ADAPTATIONS AND SPECIES CARDS

Researcher: _____

Exploring Island Adaptations Lab Sheet

Directions: With your research team, compare and contrast the 'island' and mainland species cards provided by your teacher. Fill out the table below with the name of each species and differences/similarities you see between the two (observations of physical traits, environment, location, etc.). Then come up with a hypothesis of why the island species has the unique adaptation(s) that is does. See first row for an example. Then answer questions 1 – 3 with your research team.

'Island' Species	Similarities	Mainland Species	Hypothesis
Galápagos Tortoise -large size (reach over 900lbs & 6 feet in length)	-herbivores -reptiles -close common ancestor	Chaco Tortoise -medium size (reach up to 10 inches in length)	Galapagos tortoise adapted to be larger because there weren't predators on the islands.

Researcher: _____

1. Pick one species from above to give a more detailed description of your hypothesis for why they adapted differently than their mainland counterpart.

2. Why do you think species found in dunes and high elevation mountains have high endemism similar to species found on islands in the ocean? *(High endemism - have many species that can be found nowhere else and are uniquely adapted to life in that specific area)*

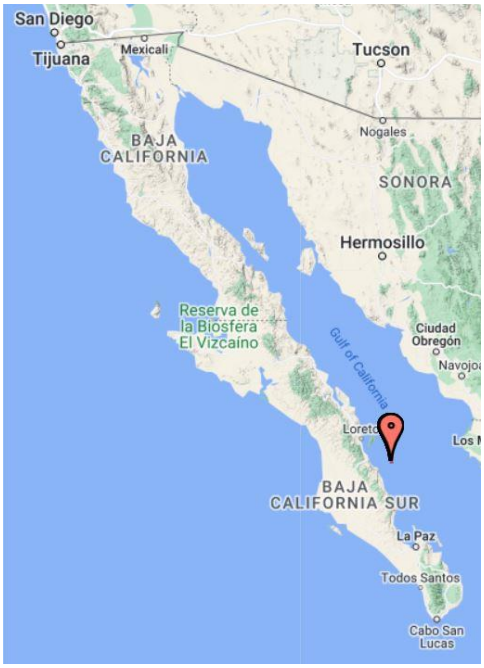
3. How do you think humans impact island species (positively or negatively)?

Isla Santa Catalina Rattlesnake

Crotalus catalinensis

Geographic Range

This species is endemic to Isla Santa Catalina, a 40 km^2 island in the Gulf of California, off the coast of Loreto, in Mexico.



Habitat

The island topography is composed of rocky hillsides separated by wide and narrow sandy arroyos (dry creeks) bearing the typical Sonoran Desert vegetation. This species occurs mainly in heavily-vegetated arroyos, but can also be found on rocky and scrubby hillsides, beneath roots and rocks or even in open areas of sandy soils. It is mainly nocturnal, hunting for prey at night.

Diet

Most of its diet (70%) is composed of the endemic Catalina deer mouse, the only ground mammal species on the island.

Predators

None

Western Diamondback Rattlesnake

Crotalus atrox

Habitat

The species' habitat encompasses arid and semi-arid regions, from plains to mountains and from sandy flats to rocky uplands, including desert, grassland, shrubland, woodland, open pine forest, river bottoms, and coastal. In southeastern Arizona, this snake is more numerous in desert scrub than in semi-desert grassland. It hibernates in rock crevices or cavities or sometimes in animal burrows or under other cover. Hibernation sometimes occurs communally in brushy upland ridges.

Geographic

Diet

Carnivores. They feed on small mammals such as chipmunks, prairie dogs, voles, woodrats, rabbits, ground squirrels, and also birds, lizards, and even fish.

Predators

A variety of larger mammals and birds, such as coyotes, foxes, hawks, and owls

Long-clawed Sand Scorpion

Vejovoidus longiunguis

Geographic Range

This species is only found in the Vizcaino Desert, Baja California Sur, where it is endemic and occurs in extremely high densities. *(The Vizcaino Desert is the dark tan section on the map)*

Habitat

This species is uniquely adapted to the shifting sand dunes of the Vizcaino Desert. It is found only in the western coast dunes.

Diet

Opportunistic feeders. Will eat a variety of insects, centipedes, spiders, and even other scorpions

Predators

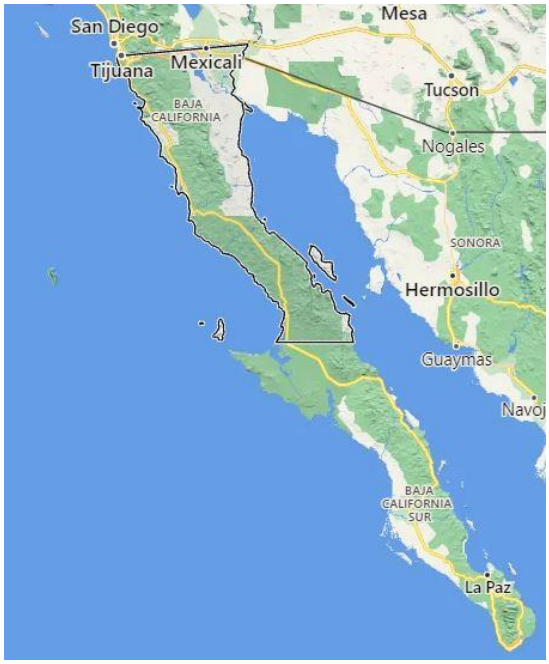
Bats, owls, snakes, rodents, spiders

Baja California Bark Scorpion

Centruroides exilicauda

Geographic Range

This species is found across Baja California Sur. It is one of the most common scorpions in the peninsula.



Habitat

The bark scorpion can be found in many places due to its ability to climb. It can be found not only under rocks or in rock crevices, but also in trees or high on rock walls. They prefer cool and moist areas and can be found in crevices, under pieces of bark, under rocks, under bricks and in houses.

Diet

Opportunistic feeders. Will eat a variety of insects, centipedes, spiders, and even other scorpions that they find in plants.

Predators

Bats, owls, snakes, rodents, spiders

Guadalupe Caracara - extinct

Caracara lutosa

Geographic Range

Before going extinct in the early 1900's, this bird inhabited Guadalupe Island. It was endemic to this island (found nowhere else).

Habitat

Preferred open, lowland habitats.

Diet

Because they are raptors, we know that they were carnivores. They likely fed on small mammals, reptiles and amphibians and that they were also carrion feeders - meaning they fed on animals that they found already dead.

Predators

No natural predators. Hunted to extinction by humans.

Crested Caracara

Caracara plancus

Geographic Range

Found from the southern United States through Central and South America.

Habitat

Crested Caracaras nest and forage in open areas year-round, and are found from grasslands and deserts, to rangelands and scrubby areas, from sea level to around 10,000 feet. They tend to avoid areas with thick ground cover as it prevents them from getting a running start to take flight.

Diet

Omnivores. They eat primarily carrion (dead animals), but they also eat live prey including insects, fish, reptiles, amphibians, birds, and mammals.

Predators

Eggs and young are vulnerable to predation by raccoons and crows. Healthy adults aren't typically vulnerable to predation.

APPENDIX D

PROBLEM-BASED LEARNING

Introduction to Problem-Based Learning
Problem-based learning (PBL) is an instructional method of hands-on, active learning centered on the investigation and resolution of messy, real-world problems. These are open-ended problems with no one "right" answer. Students work as self-directed, active investigators and problem-solvers as a class or in small collaborative groups. During the learning, a key problem is identified and a solution is agreed upon and implemented. Teachers adopt the role of facilitators of learning, guiding the learning process, and promoting an environment of inquiry.

Follow this link and click "Download a Sample Chapter" to read an excerpt from Problem-Based Learning in the Life Science Classroom by NSTA Press. *We recommend reading over the following pages: vii-viii, 17-36, and 45.* This will prepare you to facilitate the following two problem-based activities with your students.

PROBLEM 1:
INTRODUCED SPECIES ON ISLA GUADALUPE

Keywords and Concepts

- **Competition** - interaction between organisms, populations, or species, in which birth, growth, and death depend on gaining a share of a limited environmental resource
- **Introduced species -** a species that has been intentionally or inadvertently brought into a region or area
- **Endemic -** (of a plant or animal) native and restricted to a certain place
- **Native -** when a species lives in an area because of the natural environment, not human change

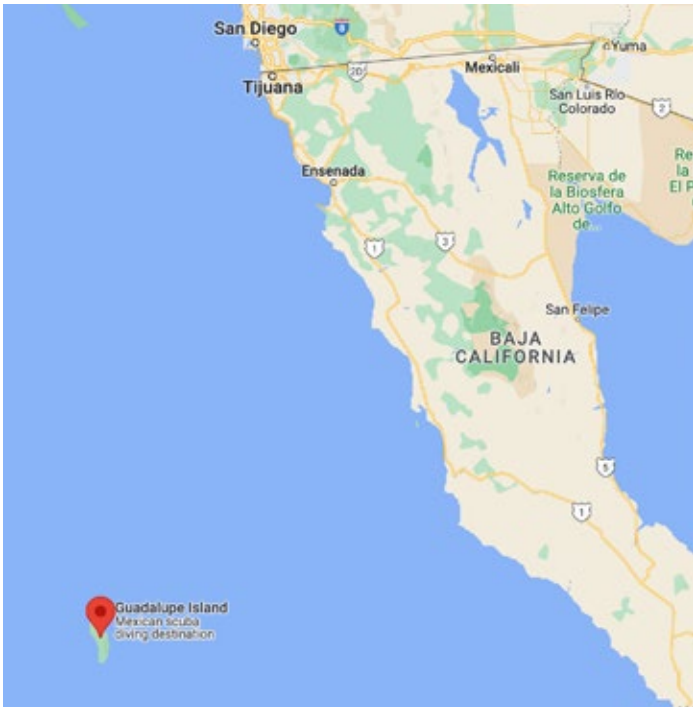
Problem Overview

- Researchers in Baja California are concerned that a growing population of goats and cats will harm the bird and plant species of Isla Guadalupe. Students are asked to evaluate the problem and propose possible actions to fix the problem.

PAGE 1: THE STORY

Changes on Isla Guadalupe
Isla Guadalupe is home to many endemic plant species and at least 10 endemic bird species. In 1602 it became the westernmost island of Mexico. In the early 1800s, whalers came upon Isla Guadalupe and let goats loose to be a source of meat for whalers during their time at sea. Along with the goats came escaped mice, cats, and even dogs - and with no predators to check their population growth, they quickly spread over the island.

Your Challenge: *Determine how concerned researchers should be with the presence of goats and other feral animals on Isla Guadalupe and what actions should be taken to protect native Isla Guadalupe species. Back your claim with evidence.*



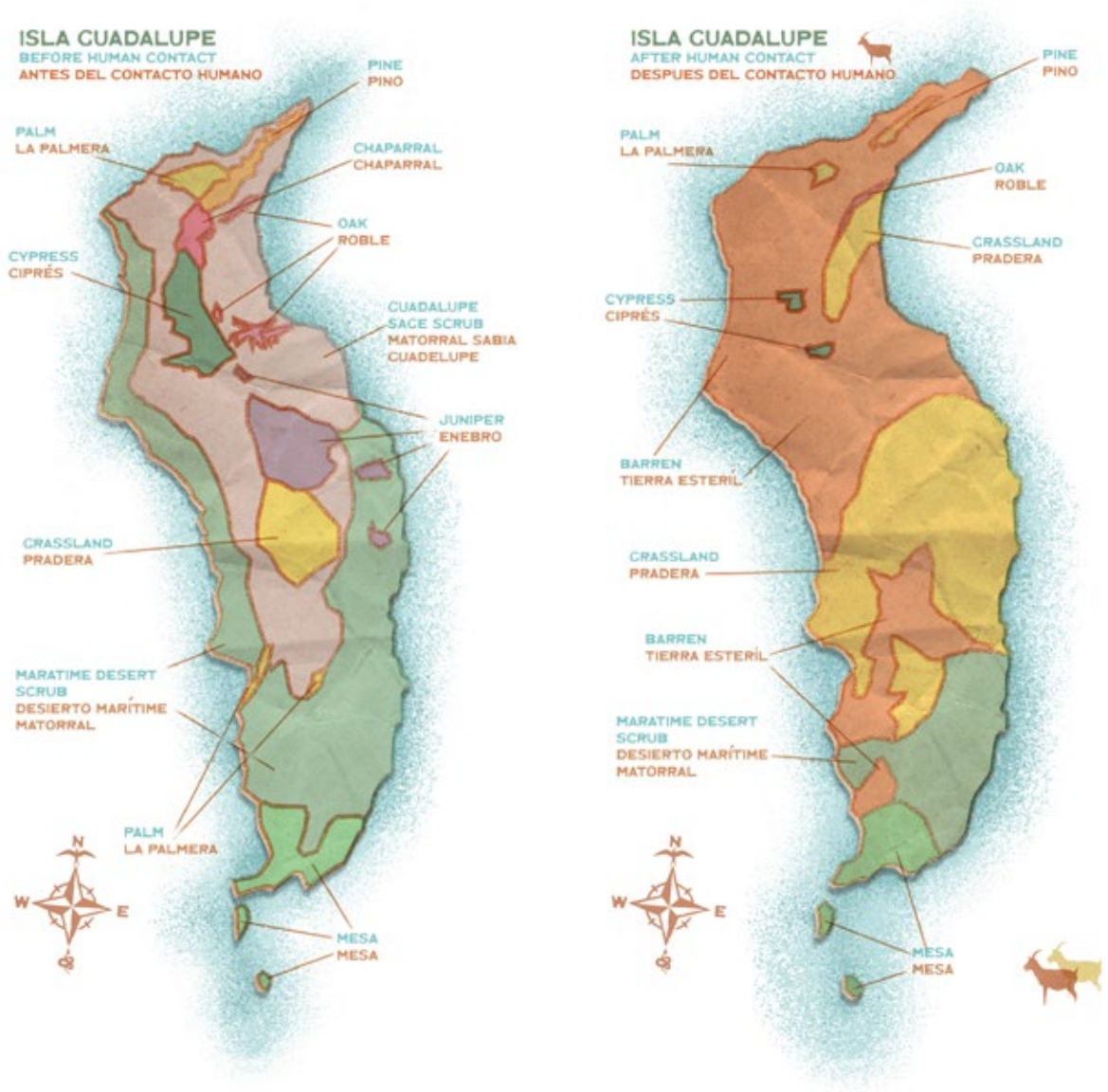
WHAT DO WE KNOW?	WHAT DO WE NEED TO KNOW?	HYPOTHESES

PROBLEM 1:
INTRODUCED SPECIES ON ISLA GUADALUPE

PAGE 2: MORE INFORMATION

Changes on Isla Guadalupe
It was noted by naturalists that many of Isla Guadalupe's birds were unusually tame, as is seen on other isolated islands. The endemic birds and plants of Isla Guadalupe were adapted to life with no natural predators or grazers to harm them. This is no longer the case with the addition of cats, which are known to be voracious hunters of birds, and goats, which are intense grazers. In 1870, a naturalist named Palmer reported that thousands of goats lived on the island, but although the animals were thriving, they had not yet damaged most of the native flora and fauna irreparably. However, in the 1900s as naturalists returned to the island, they noticed big changes in the habitat types and landscape of the island *(see graphic below).*

Is there cause for alarm? What, if anything, should be done with the goat and cat populations?



Your Challenge: *Determine how concerned researchers should be with the presence of goats and other feral animals on Isla Guadalupe and what actions should be taken to protect native Isla Guadalupe species. Back your claim with evidence.*

PAGE 3: RESOURCES

Changes on Isla Guadalupe

**These texts are provided for facilitators to gain more knowledge about the context and to see what solutions have been used to fix the problem. Sections of these texts can be provided to students to give more context to the problem and to be a resource to answer their questions from the "What do we need to know?" section. Facilitators should leave out any sections of proposed or enacted solutions so that students can come up with their own solutions.*

History and status of the avifauna of Isla Guadalupe, Mexico. Jehl, Joseph R., Jr., and William T. Everett 1985. Transactions of the San Diego Society of Natural History 20(17):313-336. Published: 30 January 1985

San Diegan finds rare plants on Guadalupe Island - The San Diego Union-Tribune (sandiegouniontribune.com)

Guadalupe, 250 miles south of San Diego, eaten away by goats | San Diego Reader

The Nat | Isla Guadalupe (sdnhm.org)

PROBLEM 2:
FUTURE OF THE SAN QUINTIN KANGAROO RAT

Keywords and Concepts:

- **Extinct** - (of a species, family, or other group of animals or plants) having no living members; no longer in existence
- **Restoration** - the practice of renewing and restoring degraded, damaged, or destroyed ecosystems and habitats in the environment by active human interruption and action

Problem Overview:

It had been 30 years since the San Quintín kangaroo rat was seen, and it was thought to be extinct. But in 2017 a group of scientists working in Baja California rediscovered this species in the middle of abandoned farmlands. The problem is, farming may soon resume in this habitat, making the future of this species uncertain. Students are asked to come up with solutions to reduce human impacts on this threatened species.

PAGE 1: THE STORY

Rediscovery of the San Quintín Kangaroo Rat
In the 1980s, farmers in western Baja used high amounts of rodenticides to protect their crops from rodents. This led to the decline of the San Quintín kangaroo rat, and by the late 1990s it was thought to have gone extinct. That is, until 2017 when a group of Nat researchers caught one in a live trap as part of a monitoring project! They took measurements and other data from the specimen and then released it back into its habitat. Scientists believe the species made a comeback because the fields in which the animals were found were no longer used for farming—a lack of water had caused farmers to resort to other, more water-efficient agriculture fields. This meant that many old agricultural fields were abandoned, leaving room for this kangaroo rat to survive. However, just because the old agricultural fields are abandoned now does not mean that they always will be.

Your Challenge: *Determine the next steps the research team should take to keep the San Quintin kangaroo rat from going extinct. Back your recommendations with evidence.*

WHAT DO WE KNOW?	WHAT DO WE NEED TO KNOW?	HYPOTHESES

PROBLEM 2:
FUTURE OF THE SAN QUINTIN KANGAROO RAT

PAGE 2: MORE INFORMATION

Rediscovery of the San Quintín Kangaroo Rat
In 2018, large industrial plants were created to remove saline from sea water, increasing the amount of water available for agricultural companies to use in their fields. Old, abandoned agricultural fields were revived with this new availability of water *(see graphic to the right).* As shown by their near extinction, the San Quintín kangaroo rat cannot survive in working agricultural lands. This species needs large, flat terrain in order to survive. They build a large network of burrows underground and have long, open runways between burrow entrances.

Your Challenge: *Determine the next steps the research team should take to keep the San Quintin Kangaroo Rat from going extinct. Back your recommendations with evidence.*

APRIL 2018

APRIL 2017

PAGE 3: RESOURCES

Rediscovery of the San Quintín Kangaroo Rat

**These resources are provided for facilitators to gain more knowledge on the context and to see what solutions have been used to fix the problem. Sections of these texts can be provided to students to give more context to the problem and to be a resource to answer their questions from the "What do we need to know?" section. Facilitators should leave out any sections of proposed or enacted solutions so that students can come up with their own solutions.*

Tremor, Scott & Vanderplank, Sula & Mellink, Eric. (2019). The San Quintín Kangaroo Rat is Not Extinctv. Bulletin, Southern California Academy of Sciences. 118. 71. 10.3160/0038-3872-118.1.71.

"Extinct" San Quintín Kangaroo Rat Still Exists | Sierra Club

The San Quintín Kangaroo Rat: Rediscovery and Conservation (sdnhm.org)

Research Talk on San Quintin Kangaroo Rat: https://www.facebook.com/watch/?v=2826306084314047

APPENDIX E

MURAL ARTIST BIOGRAPHY AND THE NAT BLOG POSTS

Mural Artist Biography

Néstor "SPEL" Mondragón was born in Tijuana, Baja California. He trained professionally in plastic arts at the Autonomous University of Baja California and graphic design at the University of the International Californias. Spel began as a street artist through the use of graffiti, experimenting with various techniques and materials. He landed his style quickly through the technical knowledge learned from his time at university along with his practice on the streets.

His work features bold, unsophisticated lines inspired by his childhood love of comics. He aims to connect with people through art by creating pieces that represent social and urban topics of personal interest. Spel says that there is an intention every time he paints, trying to put a little color in the day of a spectator. He hopes that his murals will break the monotony of the day and make people smile.

To date, he has had four individual exhibitions: *Historias de flores* (2012, 2013), *Los Normales* (2010), *Trial and Error* (2010), and *Pink Cigarette* (2007). He also has participated in several collective exhibitions and created several murals in the Southern California and Baja California regions. See below for an example of one of his murals.

Close up detail of Spel Uno Mural

Conserving the Dunes of Baja California

The peninsula of Baja California is home to miles of pristine coastline—some of the longest stretches of undisturbed coast in North America. Prime spots for future development of luxury homes and resort hotels, the area's coast and the sand dunes associated with it are at risk of environmental degradation.

Entomologists from the Museum, along with scientists in Mexico, are studying the insects of these unique ecosystems in order to understand the ecology of these dunes. The goal is to provide data that allows decision makers in Mexico to better conserve and manage this precious resource.

Living in dry sandy soils can be tough and requires special adaptations. Those special adaptations make some insects really good at living in dunes, but not well-suited for living in other habitats. Over time, these species have evolved to become sand specialists and are only found in dunes. The same dry conditions challenge the plants. As a result, insects have coevolved with the plants they pollinate, and the endemic plants and insects are essential to each other. Although scientists have a good understanding of the distribution of dune-specialist plants on the dunes of the peninsula, our knowledge of the insect distribution there is in its infancy.

Who cares? If we know about the plants, isn't that enough to make informed conservation decisions? Unfortunately, no. The fact plants potentially can be grown in another spot can become an excuse for development of pristine areas with promises of restoration mitigation in other areas. ("We can develop this area and replant the endemic plants over here and recreate the habitat.") As it happens, however, restoring a habitat requires more than just planting the right plants. To inform conservation and management so that an ecosystem can thrive, we need to understand the diverse organisms in it—and that includes insects.

Museum entomologists are in the first year of this project, which includes extensive field work, sampling of dune insects by teams from both sides of the border, a genomic study, and a dune "summit" of key researchers and representatives from government agencies and conservation organizations. Data will be shared with managers of regional protected lands and with CONABIO, Mexico's government agency in charge of biodiversity and conservation science.

Discovering the Amphibians and Reptiles of Baja California

by Curator of Herpetology Dr. Bradford Hollingsworth on April 7, 2017

The discovery of the Central Peninsular Alligator Lizard (Elgaria velazquezi) on October 29, 1997 at Cumbre de San Pedro, Sierra Guadalupe, Baja California Sur, México.

Twenty years have past since I found myself rolling rocks on top of Cumbre de San Pedro deep in the heart of the Baja California peninsula. It was October 1997 and our binational expedition to the Sierra Guadalupe had begun to scatter in its third week in the field. I joined up with the botanists Jon Rebman and Norm Roberts to push to the top of the mountains because we heard stories of a new road that crested the highest ridges.

One may argue if it was really a road or merely a goat trail, but we made it to the top of the pass. And after two days of searching, the sight of a magnificent, large alligator lizard put a lump in my throat. The memory feels like yesterday. A first for the region.

The discovery led to the description of a new species published in 2001. My graduate advisor Lee Grismer and myself proposed the name *Elgaria velazqeuzi*, after Victor Velázquez, who runs El Serpertario de La Paz. At the time, I knew the difficulty of the scientific process and the rarity of species discovery, especially in a region having been explored for almost two centuries.

The first reptile collections from Baja Califonia date back to Paul-Émile Botta, a naturalist onboard the French ship *Héros*. The *Héros* circumnavigated the globe between 1827 and 1829 as a trading vessel. With stops in La Paz, and possibly Loreto, Mr. Botta explored only a limited area of the peninsula. Life for early naturalists was hard, so not exploring deep into the mountains is easily forgiven. While he never collected alligator lizards, his specimens led to the descriptions of four new species of reptiles.

The secret lives of alligator lizards also remained unknown to William Gabb, an American naturalist, who crossed the peninsula from coast to coast 11 times during his 1867 expedition from Cabo San Lucas to San Diego. Mr. Gabb makes no mention of seeing alligator lizards during the course of his travels, but his collections led to the description of *Phyllorhynchus decurtatus*, or Spotted Leaf-nosed Snake, in 1868.

Léon Diguet, a French naturalist with the El Boleo Mining Company in Santa Rosalia from 1889 to 1892, also had an opportunity to discover alligator lizards. Mr. Diguet explored well beyond the mining district and made natural history collections from the interior of the peninsula. His collections led to the description of *Bogertophis rosaliae*, or Baja California Rat Snake, but again, alligator lizards went undetected.

Today, with almost 200 years of discovery, from early naturalists to trained herpetologists, finding new species of amphibians and reptiles in Baja California has become challenging. The era of species discovery is in its final chapter and the nature of the science is also changing.

We currently recognize 160 species of amphibians and reptiles in Baja California and it is unlikely new forms will be discovered by field explorations. Over the next couple of decades, scientists will redefine taxonomic diversity by analyzing our current state of knowledge. Instead of rolling rocks in search of secretive lizards, we're exploring genomes of already described species in hopes of discovering the region's true diversity.

Ending the era of species discovery opens the door for the next. The Amphibian and Reptile Atlas will bridge this transition and accommodate the last taxonomic changes, while citizen scientists contribute fine-scale distribution data to each species. The growth in knowledge will aid conservation efforts to protect species and ecosystems under threat. For me, the complete understanding of the region's amphibian and reptile diversity will bring rewards greater than can be imagined.

Caption: Alligator Lizard habitat in the Sierra Guadalupe, with Jon Rebman collecting plants in the distance.

International Team Discovers Large Cave-Dwelling Spider

By Michael Wall, PhD

Researchers at the San Diego Natural History Museum, along with experts from Mexico and Brazil, have described a new species of large cave-dwelling spider, the Sierra Cacachilas wandering spider (*Californctenus cacachilensis*). Related to the notoriously venomous Brazilian wandering spider (*Phoneutria fera*), the Sierra Cacachilas wandering spider was first discovered on a collaborative research expedition in 2013 into a small mountain range outside of La Paz in Baja California Sur, Mexico. Four years later, after careful documentation and peer-review, the species and genus was deemed new to science and the discovery was published in Zootaxa on March 2, 2017.

The Discovery

"The first evidence we found of this species was a shed exoskeleton in the cracks of a rock overhang," said Jim Berrian, field entomologist at the San Diego Natural History Museum and one of the authors describing the new species. "The exoskeleton was abnormally big and I could tell by the eye pattern that it was in a group of spiders, wandering spiders from the Family *Ctenidae*, with very few species in Baja California Sur."

Knowing that wandering spiders are often nocturnal, Berrian and colleagues returned to the same area that evening to find the first living specimen of *Californctenus cacachilensis*. "I knew the spider was unusual, but needed to get Dr. Maria Luisa Jimenez to look at it to make sure," remarked Berrian. Dr. Maria Luisa Jimenez, a researcher at Centro de Investigaciones Biológicas del Noroeste and foremost expert on the spiders of Baja California Sur, was on route to join Berrian and colleagues as part of the expedition to the Sierra Cacachilas. "When I saw these spiders for the first time, I was very impressed by their size," said Jimenez. "In all my experience over the years collecting spiders on the peninsula, I had never seen a spider this large. I suspected that something new was waiting to be described."

Is it Venomous?

Californctenus cacachilensis is in the same group of spiders (Family *Ctenidae*) as the notoriously highly venomous Brazilian wandering spider. "Almost all spiders are venomous, but very few are dangerous to humans," said Berrian. "I got bit while handling a live specimen of *Californctenus cacachilensis* and I'm still alive. We haven't analyzed the toxicity of the venom, but most wandering spiders are not as dangerous as the Brazilian wandering spider."

What is a New Genus?

The Sierra Cacachilas wandering spider is so different from other related species that the authors of this study determined that they needed create an entirely new category for it, the genus *Califorctenus*.

“We made the case for this by comparing many species of wandering spiders from around the world and creating a phylogeny for the group,” said Dr. Daniele Polotow a researcher at University of Campinas in Brazil and expert on wandering spiders.

Scientific names reflect the distance of the relationship in the “evolutionary tree of life.” For example, humans are a species called *Homo sapiens*, and belong to a genus called *Homo*. Other primates, like chimpanzees in the genus *Pan* and gorillas in the genus *Gorilla*, are in a totally separate genera. Similarly, *Califorctenus cacachilensis* is so different that a new group had to be created for it.

An Age of Discovery and Collaboration

Most insects and spiders on the planet have yet to be discovered. There are about 1.1 million species of insects and spiders on the planet that scientists have given names, but most researchers estimate that there are two to five million that remain undescribed.

Focusing on southern California and the peninsula of Baja California, the San Diego Natural History Museum continues to invest in research, discovery, and conservation while focusing on binational collaboration. Coauthored by two Mexicans, a Brazilian, and an American researcher, the study combines multiple lines of expertise to make the case that this spider is not only a new species, but represents also a new genus. “This study is a perfect example of the importance of international collaboration and the type of research we do,” said Judy Gradwohl, president and CEO at the San Diego Natural History Museum.

Rediscovering Lost Species

by Margaret Dykens, Research Library Director on January 16, 2019

There is nothing to match the excitement of searching for a plant or animal known from many years ago in a particular area, but never seen again. Did it fall victim to extinction, was it eliminated by some environmental problem, or have scientists just not been in the right place at the right time? Sometimes these plants or animals are called “Lazarus species” because they appear to come back from death or extinction.

When plants or animals are so rare, we don’t even know if they need protection. So knowing they exist is the first step in conservation. Over the past couple of years, our researchers succeeded beyond anyone’s expectations at rediscovering Lazarus species.

In summer 2017, Mammalogist Scott Tremor and Research Associate Dr. Sula Vanderplank were surveying the San Quintín area of Baja California, which has seen major changes as natural habitat areas have been lost to agricultural use. This area was known to be the last habitat for the San Quintin kangaroo rat, *Dipodomys gravipes*, a species described as “critically endangered and possibly extinct” on Mexican federal lists. Despite exhaustive surveys, it had not been recorded since 1986—until recently. During their field monitoring, Scott and Sula captured several individuals, then observed, measured, and released them unharmed. This story made international headlines, and the team is now working hand in hand with local organizations on a conservation plan for the animal.

In addition, Scott and Sula have rediscovered the tule shrew, (*Sorex ornatus juncensis*), which was also considered extinct but now has been found in a small patch of potential habitat south of the Socorro Dunes.

Curator of Botany Dr. Jon Rebman received a grant through the National Geographic Society to track down 15 species of plants endemic to Baja California that are known only from very old type specimens. Rebman is collaborating with Dr. Jose Delgadillo at Universidad Autónoma de Baja California in Ensenada, Dr. Jose Luis Leon de la Luz at Centro de Investigaciones Biológicas del Noroeste in La Paz, and John LaGrange, a volunteer in the Botany Department.

The team’s first success came when they encountered *Astragalus piscinus*, a rare species of milkvetch last seen in 1889, when the type specimen was collected by Edward Palmer near Scammon’s Lagoon in Baja California Sur. They have also re-discovered *Physaria palmeri*, Palmer’s Bladderpod, a plant last seen in 1884 when it was collected by the naturalist Charles Orcutt, who first found it in Topo Canyon, in the Sierra de Juarez of northern Baja California. By studying historic maps, carefully reading Orcutt’s original field notes from our Museum archives, and noting accompanying species of plants, the team was able to make a very educated guess about where to search, and it paid off.

More recently, Jon and a team of field botanists were collecting closer to home in Camp Pendleton along the Santa Margarita River, when they found a nutsedge, *Cyperus esculentus* var*. macrostachyus*. This represents only the second time this native plant species has been documented in California, the first being in 1885 by Charles Orcutt, with only "San Diego" listed as the locality.

The Herpetology Department can also claim their own Lazarus species. The Couch's Spadefoot (*Scaphiopus couchii*), a toad-like frog, was rediscovered on Isla Cerralvo, off the coast of La Paz in Baja California. Couch's Spadefoot had been reported as present on the island by Richard Etheridge in 1960, but there had been no additional observations since then. In 2016 during a binational rapid assessment survey, Curator of Herpetology Dr. Bradford Hollingsworth and a team of scientists rediscovered this species behind the island's coastal dunes—only the second documented individual after 56 years.

In terms of range extensions, Curator Phil Unitt and Dr. Lori Hargrove of our Birds and Mammals Department have documented successful nesting and colonization of Zone-tailed Hawks in the Mojave National Preserve for the first time, which represents a substantial breeding range expansion northward from Baja California and Arizona. As part of the effort to retrace Joseph Grinnell's 1914 survey of this area and document changes occurring 100 years later in the California desert, the museum scientists state it is now likely that several pairs of nesting Zone-tailed Hawks have made their homes in the Mojave.

All of these discoveries are validation of the important work done by our research scientists who study Southern California and the Baja California peninsula. The data they collect help stakeholders make appropriate land use decisions, since we must know what plants and animals occur where in order to decide how areas might be protected for the future.

Caption: The Museum's botany team discovered lagoon milkvetch (Astragalus piscinus) in Baja California. It was last known to have been seen in 1889. Photo by Jon Rebman.

This Wild Life: California's Favorite Frogs—Where Are They Now?

Posted by Cypress Hansen, Science Communications Manager

When the team finds an egg mass, they record all sorts of data on it—such as GPS location and estimated age—before they collect it.

As soon as the soggy, white mesh bag emerged from its jar, a hush fell over the group. We huddled close, watching and snapping photos as ecologist Adam Backlin from the U.S. Geological Survey lowered the bag into a rinsing bin.

Its contents? Several hundred California red-legged frog eggs from Baja California.

That afternoon marked the last red-legged frog translocation trip of the season. The eggs in Backlin's bag were the third generation of frogs transported from Baja California to two protected ponds in rural southern California since this translocation project—overseen in part by The Nat's Curator of Herpetology Dr. Brad Hollingsworth—began in 2020.

Before then, red-legged frogs were extinct in Riverside and San Diego counties, and it has been our collective goal to bring them back.

After carefully rinsing the pea-sized, boba-like eggs in three separate tubs of fresh pond water (a biosecurity measure to avoid contamination between habitats), Backlin headed for the water's edge. All 14 of us followed, craning our necks like parents sending off their kids on the first day of school.

There were people from several conservation entities gathered around, including The Nat, the United States Fish and Wildlife Service, the U.S. Geological Survey (USGS), The Nature Conservancy, and the Mexican nonprofit organization Conservación de Fauna del Noroeste (FAUNO).

All of them were buzzing with excitement as Backlin waded into the water and slipped the eggs into a larger mesh enclosure staked in the shallows. His task at this moment was simple, but several years of planning, collaboration, and slogging through frog ponds went into making it possible.

Frog-hopping across the border

Earlier that morning—much earlier—The Nat's Herpetology Collections Manager Frank Santana, Field Technician Jess Barba, and volunteer Tom Belknap began their workday. It was a numbing 28 degrees in the mountains of Baja California, and they had a long day ahead of them.

By 5:30 AM they reached the ponds at Rancho Meling, an eco-ranch with a year-round stream and several wetland ponds—two of which were created by a collaborative effort by our team, FAUNO, The Wildlife Project, and The Sonoma Mountain Ranch Preservation Foundation in 2018.

"It's a really nice setting," says Barba. "The ponds can be murky and smelly in some places, but that's normal. The stream is clear, redwing blackbirds are all over, and there's lots of duckweed, which the frogs like."

In the dark before dawn, frost formed on eyelashes and fingers reddened as the team filtered fresh water, prepped the coolers, and stowed the eggs. "I couldn't feel my toes the whole time," says Barba. "Even the water was warmer than the air."

Fortunately, they had done all their wading and collecting the day before. Gathering and separating frog eggs requires patience and a gentle touch. As Hollingsworth describes it, "it's like trying to separate a cantaloupe-sized mass of Jell-O, underwater, with your bare hands."

In this case, the freshest, youngest eggs are the prized catch. Younger eggs are less likely to hatch during transit, and after weeks of monitoring, the team had timed their harvest perfectly. Their eggs were less than a day old.

"Eggs are much easier to manage than a bunch of nervous tadpoles," says Barba. "They're also more resistant to jostling because the jelly coating around the egg acts like a built-in car seat."

By 6:15 AM, Barba, Santana, and Belknap were on the road with a five-and-a-half-hour drive ahead of them. For these long drives, they keep the eggs in heavy-duty YETI coolers retrofitted with temperature gauges, oxygen tubes, ice packs and extra padding. The developing frogs must stay within a few degrees of their source-pond's temperature, or the stress of warming up and cooling down could endanger their survival.

Crossing the Tecate entry point was a breeze—a welcome change from the previous week, when it dragged on for two hours. As soon as they were on U.S. soil, the early morning crew passed the precious cargo off to USGS biologists Jon Richmond and Robert Fisher, who split up and shuttled the gooey goods toward their new homes.

While Richmond and Fisher traced the highways northward, Hollingsworth and the folks from our partner organizations assembled at the two receiving ponds located near Murrieta in Riverside County and south of Palomar Mountain in San Diego County.

Getting a clear connection

For the first time since this project began, our colleagues at FAUNO, Director Anny Peralta-García and Research Coordinator Jorge Valdez-Villavicencio, joined us at the pond near Murrieta, on the Santa Rosa Plateau Ecological Reserve. Their long-awaited presence added another layer of excitement to the day, as previous visits were cancelled by pandemic-related border closures.

"These frogs need people on both sides of the border to help them," says Peralta-García. "But it's so great to follow their whole journey and finally see where they end up."

For FAUNO, these frogs are one conservation priority among many. The organization's goal, says Peralta-García, is to see entire wetland ecosystems make a comeback, not just a single species.

As the largest native frog west of the Mississippi, the red-legged frogs are a great candidate to kick off this conservation mission. Tadpoles and adults consume large amounts of algae and insects (including mosquitoes) which, in turn, keeps pond waters clear and more habitable for fish, other herps, and plants.

Another goal is to improve habitat connectivity on both sides of the border. So far, this project has narrowed the gap between red-legged frog habitats from 250 miles down to about 150, says Peralta García. "Our dream is to see [the frogs'] range connected between southern California and Baja California, and to see all the associated species return."

When Fisher arrived with the eggs, everyone sprang into action: Waders were donned, cameras clicked, clipboards emerged. We formed a line behind the cooler-carriers, hopped a couple barbed-wire fences, and wrapped around an old cattle pond lined with tall grasses.

This pond is already home to Baja-born frogs that were translocated by The Nat and our partners in 2020 and 2021, so we expect the newbies to feel right at home once they hatch in two-weeks' time.

Like its waters, the future of that small cattle pond is getting clearer each year. With three generations of frogs now making their way, the next milestone is self-sufficiency in the form of breeding. We have yet to detect any mating calls from the frogs since they were reintroduced in 2020, however, it takes them about three years to mature.

Throughout the spring, we'll be wading through the muck to monitor the younglings and eavesdropping on the adults with acoustic recorders. We're hoping to hear the faint, grunting mating calls from the males, or spot new egg masses from the females.

The translocations, though, were done for the season. Backlin zipped up the mesh enclosure, everyone clapped, someone yelled "good luck, eggs!" And until our favorite frogs are back on their feet, we'll return this time next year with another batch of Baja babies to do it all again.