Conceptor Magazine

Environmental Change Biodiversity Oceans Conservation Community and Human Health





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ConCiencia Magazine: A Science Magazine of the Galapagos Science Center, a Collaborative Partnership Between the University of North Carolina at Chapel Hill and the Universidad San Francisco de Quito

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Editorial Comments

e are happy to introduce this 3rd edition of ConCiencia to our friends and colleagues in Galapagos, Ecuador, the United States, and across the world. As with past editions, this magazine highlights the innovative research done by faculty, students, and other researchers at the GSC, the educational opportunities created for students locally and globally, and the community outreach initiatives led by our dedicated staff and partners. The research projects featured in this volume represent just a small number of the over 100 on-going collaborative, interdisciplinary projects that are being conducted by over 125 researchers affiliated with the GSC through the Universidad San Francisco de Quito, the University of North Carolina at Chapel Hill, and our International Galapagos Science Consortium. Similarly, the presented education and outreach projects are just a few examples of the numerous programs led by GSC and our partners, including the

Galapagos Conservancy, that bring our scientific findings to over 2500 local children and families yearly.

Over the past 11 years, the GSC has expanded our research, education, and outreach programs on the marine, terrestrial, and social systems of the archipelago and how these systems interact to shape animal, human, and ecosystem health. Over the next ten years and beyond, we will focus on how our changing climate will influence the health of the oceans, the biodiversity of the islands' flora and fauna, and the well-being of individuals and communities. Importantly, we are committed to using this innovative science to find solutions to these challenges. As shown in the articles in this edition, this work is well underway.

The first article describes how researchers from the GSC and Galapagos National Park work in partnership on oceanographic cruises to monitor ocean temperatures and the biodiversity of marine life across climatic events like El Niño. Other articles, **Corals in Galapagos: Thermal tolerances and restoration and Are marine species becoming hungrier?**,

describe the impacts of changing ocean conditions on the survival, growth, and distribution of key marine species. Along with this work with marine species,

GSC researchers are also monitoring the biodiversity of terrestrial plants and animals. Genomic study of native and endemic grasses of the Galapagos Islands and Galapagos Game of Thrones: The fight for survival between endemic and introduced geckos examine the genetic and physiological adaptations of endemic plants and animals to unique environment of the Galapagos and how these species may be threatened by the introduction of non-endemic species. The first unique genetic digital fingerprint of each species in Galapagos is a reality thanks to the Barcode project describes how our scientists, in collaboration with the local community, are working to preserve this information about the biodiversity of the islands' species

by extracting and storing DNA for future conservation efforts. Human and community health are the focus of the remaining articles. Burdens of Paradise describes the challenges faced by island residents in obtaining healthy foods and clean water and the impacts this has on their physical and mental health. The remaining chapters describe how, working together, the GSC, our partner organizations, and the community can sustain the health of the island ecosystems through education and opportunities for sustainable economic development.

As these articles in *ConCiencia* show. the Galapagos Islands present a unique opportunity to "make 'big discoveries" in science, to have enriched learning opportunities in which students can apply what they learn in the classroom to real-world problems, and to have impact on communities locally and globally. This work and our on-going collaborations with the Galapagos National Park and the participation of the community will help ensure that the Galapagos remains a healthy and sustainable island ecosystem for many future generations.



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The Galapagos Science Center (GSC), run jointly by the University of North Carolina at Chapel Hill and the Universidad San Francisco de Ouito in Ecuador, is the only university science facility of its kind on the Galapagos Islands, For over 10 years the GSC has been a hub of collaborative and interdisciplinary research, education, and community outreach. The GSC is committed to advance science and conservation in the Galapagos Islands and to extend a richer, more complete understanding of island ecosystems and the threats to their sustainability to the world

The 20,000-square-foot GSC houses four state of the art laboratories, each with a dedicated research focus: terrestrial ecology, marine ecology and oceanography, microbiology and genetics, and data science and visualization. The GSC is located in Puerto Baquerizo Moreno, San Cristóbal Island, Galapagos Archipelago.





The Galapagos Science Center (GSC) is an interdisciplinary research facility whose mission is to lead in the understanding of human and environmental interactions on a local and global scale through integrated scientific research, experiential education, and community outreach.

Research



Develop interdisciplinary research projects for the conservation and sustainability of the Galapagos Islands and globally through 5 basic pillars: environmental change, community & human health, conservation, oceans, and biodiversity.

Experiential education



Provide hands-on learning experiences for local and international students across an array of interdisciplinary research projects thanks to partnerships with the Galapagos National Park and other local public institutions.

Community Outreach



Contribute to sustainable development and greater environmental awareness in the local community to better understand the complex interactions among people and the environment in which they live.

Global Partnerships



Create a scientific network that is powered by a diversity of thought, perspectives, techniques, approaches, visions, and a data infrastructure that are leveraged through integrative science to create a collaborative global network of institutions and scholars for the innovative study of island ecosystems. Interdisciplinary research that furthers science and contributes to the conservation and sustainable development of the Galapagos is our number one priority. The GSC brings together international researchers to tackle the grand challenges of our time and, in turn, inform policy decisions. Since 2011 we have conducted over 100 research projects across 5 main areas of research. Throughout this edition of ConSciencia we will highlight research across these areas and showcase their impact.



Team of researchers from Galapagos Science Center and Galapagos National Park seek to protect marine biodiversity and understand climate variability through marine expedition

Environmental Change

1.



Authors: Victoria Castro and Karina Vivanco

he Galapagos Islands are famous for their biodiversity and have been the subject of scientific study since the time of Charles Darwin in the 1830s. This extraordinary biodiversity is due to their location at the convergence of three marine currents that create unique ecological conditions both within and outside the archipelago.



Since 2014, the Directorate of the Galapagos National Park (GNP), the Universidad San Francisco de Quito (USFQ), and the University of North Carolina at Chapel Hill (UNC) - through the Galapagos Science Center (GSC) - saw the necessity to generate a project that would allow them to navigate around the archipelago in order to obtain updated information on the population and health status of several emblematic species like sea lions, fur seals, marine iguanas and turtles, as well as the effects of climate variability within the Galapagos Marine Reserve (GMR). These research and scientific monitoring cruises have been carried out annually from 2014 to 2019, obtaining actual results on the adaptations these species acquire during and after warming periods such as El Niño. This climatic event is characterized by generating warming in the ocean that reduces the marine

productivity of the region, producing conditions that lead to lower availability of food for marine/coastal consumers. "The El Niño events generate food stress in several of the emblematic species of the GMR, exposing them to mortality or changes in their ecological behavior," according to Diego Páez-Rosas, GSC researcher and a professor at USFQ.

During the years 2020 and 2021, although the inter-institutional work was paused due to the COVID 19 pandemic, the GNP continued with the monitoring, generating valuable information for the management and conservation of this natural laboratory. The cooperative work between institutions and researchers allowed a new research and scientific monitoring expedition to be carried out at the end of 2022, using the same methodologies as in previous years, but this time under climatic conditions related to La Niña. *"This is the opposite climatic event* to El Niño, that is, the sea cools due to a greater amount of upwelling and there is speculated to be greater marine productivity, increasing the availability of food and providing more favorable conditions for several species. With cold water there are more nutrients, typically creating greater primary productivity, which in turn leads to a shift in dominant phytoplankton from smaller species to larger ones," adds Adrian Marchetti, GSC researcher and a professor at UNC.

In November 2022, a team of 12 researchers from USFQ, UNC, and GNP, together with 8 crew members from the Sierra Negra vessel, traveled for 16 days to a total of 14 islands and 30 specific sites, distributed around the GMR.

The research effort consisted of covering the following objectives: measure numerous oceanographic parameters, such as temperature, salinity, nutrient concentrations, primary productivity and plankton community composition that could be impacted by the La Niña conditions; monitor the emblematic species of Galapagos, including sea lions, fur seals, iguanas, and marine turtles; and evaluate the impact of plastic and microplastic on the marine environment. This information will be used by researchers and the GNP team to understand the health status of several of these species - considered bioindicators of the ecosystem - in order to evaluate the effects of climate change on the Galapagos ecosystems and potentially help with decisionmaking on how to preserve the GMR.

In order to capture this valuable data during the expedition, the research team used innovative methodologies and techniques, such as population monitoring using drones. *"Because* access to the reproductive colonies of marine iguanas is very difficult and sometimes impossible, the idea of covering these areas with an aerial view

> The 2022 research and scientific monitoring cruise was a joint effort of the Directorate of the Galapagos National Park, the Universidad San Francisco de Quito, and the University of North Carolina at Chapel Hill and was financed by the Galapagos Science Center and the Galapagos Conservancy.







is an opportunity to generate more information," comments Jennifer Suárez Moncada, a technician - park ranger at GNP.

Following the expedition, scientists returned to their respective universities and are working in their laboratories analyzing the data to create scientific information that will be delivered to the GNP and presented to the world in the form of scientific articles that are expected to be published in 2023. Some of the preliminary results include determinations that the ocean water was colder than in previous years, with a temperature range several degrees below the average for that time of vear, as well as an increase of sea lion and fur seal populations, with a higher number of offspring on the Islands of San Cristóbal, Floreana, Fernandina, and Isabela. Additionally, the marine iguana census registered a total of approximately 36,000 individuals, of which the health status of 70 specimens was monitored showing that the animals are healthy.

Responsible for the Galapagos Pinniped Monitoring Project: Dr. Diego Páez-Rosas and Dr. Marjorie Riofrío-Lazo, **USFQ** professors and GSC researchers. **Responsible for the Oceanographic Monitoring** Project: Dr. Adrian Marchetti and Dr. Harvey Seim, **UNC** professors and GSC researchers. Responsible for the Marine Iguanas and Turtles Monitoring **Project: Biologist Jennifer** Suárez and Dr. Andrea Loyola, **GNP** park rangers.

Project leaders:









The first unique genetic digital fingerprint of each species in Galapagos is a reality thanks to the Barcode project



Authors: Victoria Castro and Karina Vivanco

he Galapagos Genetic Code (Barcode) project arose in response to the economic impact caused by the COVID-19 pandemic on the Galapagos Islands and employed 79 people linked to tourism who had lost their income. Additionally, recognizing that there is limited knowledge about all species that make up the biodiversity of the Galapagos, this project is important both for researchers seeking to learn more about ecosystem health and preservation, and for the local community seeking to conserve their territory.



The Galapagos Barcode project aims to catalog the biodiversity of the Galapagos Islands using noninvasive sampling techniques, such as "Environmental DNA (eDNA)" with a focus on marine-coastal ecosystems, and laboratory techniques such as "Metabarcoding" that are capable of generating large amounts of information. This has been done in order to build a more equitable, sustainable, and resilient future in Galapagos, improving knowledge about natural biodiversity and promoting community participation.

The project consisted of several stages, including participant selection, training, equipment acquisition,

data collection, information processing, and analysis of results. "Often, scientists are thought of as one group of people and locals as another group of people, who really have nothing in common. During the pandemic, this initiative found a point where community and science could come together and work together. Participants were also able to learn about science, and what different techniques are used, from species recognition to the use of technology in genetics labs," said Andy Russell, Professor of Animal Behavior at the University of Exeter in the UK.

The process of selecting and training personnel for the Galapagos Barcode project involved selecting 79 people from among 446 applicants. The training was conducted virtually by professors from USFQ in Ecuador, the Charles Darwin Foundation, and international researchers from the University of Exeter in the UK, the University of California at Berkeley, and the Monterey Bay Aquarium Research Institute.

From September 2020 to October 2022, the Galapagos Barcode project carried out 28 field trips in the Galapagos Marine Reserve, collecting 1,896 botanical, water, soil, and endemic and invasive species DNA samples, and sequencing 466 assays.

To carry out the project, three laboratories were equipped on three islands: the GSC on San Cristóbal Island, ABG facilities on Santa Cruz Island, and the Municipal Government facilities on Isabela Island. Each laboratory had stateof-the-art sequencing technology for the analysis of genetic barcodes and the collection and research of species DNA.



The Galapagos Genetic Code (Barcode) project was created through collaboration between the Galapagos Science Center (GSC), the Universidad San Francisco de Ouito (USFQ), the University of Exeter in the UK, the Agency for Regulation and Control of Biosafety and Quarantine for Galapagos (ABG), and the Galapagos Conservation Trust (GCT). Project funding was made possible thanks to the support of the **Research and Innovation Fund and** the Newton Fund, both belonging to the Global Challenges Research Fund of the UK Government.

Among the preliminary results, it was observed that the soil microbiomes of Isabela, Santa Cruz, and San Cristóbal islands are different from each other, as well as along the altitudinal gradient. Additionally, it was observed that the environmental DNA methodology is capable of detecting at least twice as many species as conventional monitoring mechanisms. Therefore, standardization of this methodology will be sought to apply in the monitoring of marine coastal zones. The results analysis is expected to be completed by lune 2023.

Project leaders:

Carolina Proaño L., MSc, Project Manager GSC Quito, and Diego Ortiz, MSc, Project Manager GSC San Cristóbal are the managers of the Galapagos Barcode Project, who worked with Dr. Jaime Chaves, Dr. Diana Pazmiño, and Dr. Carlos F. Mena, researchers at GSC and professors at USFQ; Dr. Camille Bonneaud, Dr. Andy Russell, and Dr. Tomas Chaigneau, professors at the University of Exeter.





Genomic study of native and endemic grasses of the Galapagos Islands



Authors: Carolina Armijos, Diego Urquía and María de Lourdes Torres

The ability of organisms to respond to various signals from their environment is a fundamental aspect of their survival and adaptation. This research project aims to understand how different species of grasses respond to light, a key signal for the evolution of these and other plants. This research focuses on studying the dynamic of light in the plant canopy. Plants experience shifts between low and high levels of light over varying periods of time in their natural environment, and this directly influences how their light signal detection system operates.



This project is being led by a team of experts in diverse fields from both universities, University of North Carolina at Chapel Hill (UNC) and Universidad San Francisco de Quito (USFQ). The team has chosen Ecuador as their study location because it has a wide range of environments with many species of grasses, making it an ideal location for a deep grass genome X environment association study. The study will include environments such as alpine tundra (a unique high grassland known as páramo), tropical rainforest, riparian and littoral zones, and the Galapagos Islands.

The Galapagos Islands are of particular interest to the researchers because of their unique ecosystem and biodiversity. The islands have a high level of endemism, which means that many species are found nowhere else in the world. Additionally, the open light marine coast of the Galapagos provides a unique environment for studying dynamic light in a coastal ecosystem.

Field trips have been carried out to San Cristóbal and Santa Cruz in the search of endemic and native grasses such as Aristida divulsa. Aristida repens, Cenchrus platvacanthus, Paspalum galapageium, Paspalum redundans, Chloris virgata, and many more. Through next-generation sequencing (NGS), the genomes of Chloris virgata and Aristida sp. have already been unraveled and are being analyzed. Further research will continue to obtain more information on the genomes of mainly endemic grass species.

The Genomic study of native and endemic grasses of the Galapagos Islands project is being led by a team of experts in diverse fields from both University of North Carolina at Chapel Hill (UNC) and Universidad San Francisco de Quito (USFQ). The UNC team is composed of: Alan Jones, a specialist in G-protein signaling in various organisms, who brings his expertise in mathematical modeling to understand dynamic signaling processes; Corbin Jones, an expert in genomics and population genetics who contributes his skills in analyzing genetic data; and Wenbin Zhou, a postdoctoral researcher who oversees the project execution and progress. The USFQ team, consisting of María de Lourdes Torres and Hugo Valdebenito, brings extensive knowledge in Ecuadorian plant genetics and phylogeny, geobotany, and familiarity with the Ecuadorian plant communities and ecosystems. It also includes two USFQ alumni, Carolina Armijos and Diego Urguía, who assist in the bioinformatic analysis. Altogether, they will play a key role in studying how adaptation to dynamic light shapes the physiology, development, genetics, and evolution of grasses.



Author: Margarita Brandt

t is not surprising that the El Niño events have impacted the ecosystems of Galapagos. However, the shallow coral reefs (0-20m) are perhaps the best example of this: due to the high and prolonged temperatures during the 1982-83 El Niño, 16 of the 17 structural reefs were lost, as well as 10 of the 19 coral communities (reefs mainly rocky with patches of coral). Interestingly, during the 1997-98 El Niño, the surviving corals bleached less than expected. Additionally, a 22% recovery has been estimated in the only remaining structural reef on Darwin Island, and important coral communities persist on Wolf, Marchena, Isabela, Santa Cruz, Floreana, Española, and San Cristóbal. These corals may be unique in their thermal tolerances, derived from survivors and/or new recruits. Do thermal sensitivities vary among corals from different regions? Which populations are more tolerant? What are the mechanisms of their thermal tolerances? What can we do to recover coral communities and increase their resilience?

During 2019, and for the first time for corals in Galapagos, we analyzed their thermal tolerances, using a portable "Coral Bleaching Automated Stress System". We collected coral fragments from *Pavona clavus* and *Pocillopora spp*. on the islands mentioned above (excluding Marchena), representing a wide temperature range. We found that the corals from Isabela are the most

susceptible to heat, while those from Española are the most susceptible to cold. Surprisingly, corals from Darwin, Wolf (from the warmest region of the archipelago), and San Cristóbal showed the widest range of thermal tolerances. Preliminary genetic analyses for *Pocillopora* show genotypic differences among islands: "Type 3" was found in Isabela and Santa Cruz, and "Type 1," known to be more heat-resistant, in the rest of the islands. On the other hand, the heat-resistant symbiont Durusdinium was found only in Darwin, Wolf, and San Cristóbal. We are currently conducting phenotypic plasticity analyzes to determine if differences in gene expression also explain thermal tolerances.





On the other hand, in Puerto Villamil, Isabela, we started the first mediumscale coral restoration project in the archipelago. "Galapagos Reef Revival" emerged as a pilot project to test the feasibility of the "coral gardening" method in Galapagos. We grew 240 coral fragments for 13 months, and once the viability of the intervention was proven, we finalized the pilot with the successful transplantation of coral fragments back to the seafloor. Supported by Jocotoco Foundation and Re:wild, we built a second coral nursery with a capacity of at least 2,400 fragments, recording survival rates of > 80%, considered among the highest in the region. To date, the initiative has restored approximately

1,000 m2 and is in the process of substantially increasing coral coverage in Isabela.

Determining the thermal sensitivities (and mechanisms) of Galapagos corals will provide critical information to the Galapagos National Park Directorate (GNP) on which coral communities may be more resistant and which need greater protection. On the other hand, the successful completion of the nursery in Isabela will establish the necessary protocols for the GNP to replicate methodologies in other restoration initiatives in the archipelago and thus recover and increase the resilience of these important Galapagos marine ecosystems.



The Hermatypic Coral research project is led by GSC researcher Margarita Brandt, Assistant Professor at Universidad San Francisco de Quito (USFQ). Cheryl Logan from California State University Monterey Bay (CSUMB) is a co-investigator in the thermal tolerance project, along with Caroline Rodriguez and Katrina Gimbertone from CSUMB, Daniel Barshis from Old Dominion University, and Jenifer Suárez from the GNP. Nicolás Dávalos (USFQ alumni) serves as the director of the Galapagos Reef Revival initiative, with Jenifer Suárez from the GNP, John F. Bruno from University of North Carolina at Chapel Hill (UNC), and Isabela locals Cristopher Gómez and José Barrios are also participating.





Oceans

5.

Are marine species becoming hungrier?

Author: Esteban Agudo

The ocean is getting warmer at an unprecedented rate due to anthropogenic increases in greenhouse gas emissions (mainly CO2). This has already had several consequences on marine organisms such as changes in species distribution and local extinctions. But it also has the potential to change the way species interact among each other. Species interactions (i.e., predation, competition, parasitism) determine community structure (which species are where and how many) and overall ecosystem function (the processes that allow an ecosystem to be the way it is). For example, predation determines prev abundance and distribution.

Ectotherms (cold-blooded organisms) cannot control their internal

temperature, therefore environmental temperature determines metabolic rate, which is the rate at which physiological processes occur. If metabolic rate increases with temperature, energy demand – and consequently food consumption – should also increase, affecting most species in the ocean. This means temperature plays an important role in marine community dynamics, which is the focus of my research.

I am measuring the relationship between temperature and predation rates across multiple taxonomic groups (starfish, snails, fishes). To accomplish this, I am combining experiments in the field with experiments in the lab. We built a mesocosm room in the Galapagos Science Center which consisted of 18 aquariums where we controlled water temperature. We ran predation experiments in which we measured feeding rates in whelks and starfish across multiple temperature treatments. Our whelk experiment demonstrated that consumption was low at cold temperature, peaked at intermediate temperature and decreased at the warmest experimental temperature. This curvilinear relationship was consistent with Metabolic Scaling Theory, which provided the theoretical foundation for my research.

Lab experiments can only tell so much. Currently, we are testing a similar hypothesis directly in the field taking advantage of the seasonal changes in temperature in the Galapagos, which makes it an ideal natural lab. We are conducting a field experiment to measure natural predation by utilizing cages that contain whelks and barnacles placed in a rocky reef in northern San Cristóbal.

Moreover, we measured the relationship between temperature and predation by reef fishes. We used

the squidpop protocol in which we positioned 25 stakes with dry squid as bait on multiple reefs. After one hour we returned to the sites and noted how many baits had been eaten to estimate predation rates. To utilize the spatial and temporal temperature gradient in Galapagos, we did this every two months for 15 months across six localities in the eastern island of San Cristobal. The data indicates that fish eat more in the warmer sites and during the warmer months.

Our results demonstrate that temperature plays an important role in determining predation rates, which has important implications to understand changes in Galapagos marine communities across seasons, and when exposed to climatological events such as El Niño and La Niña. Furthermore, our project shows we need to continue including ecological interactions into climate change research to better predict the future of marine ecosystems.

Esteban Agudo is a marine ecologist interested in how environmental characteristics (i.e. temperature, structural complexity) affect marine communities in a time of global change. Agudo is a PhD student in the Bruno Lab at the University of North Carolina at Chapel Hill. His dissertation combines field and lab experiments to measure how temperature models predation on Galapagos Reefs.



6.

Galapagos Game of Thrones

The fight for survival between endemic and introduced geckos

Authors: Mateo Dávila-Játiva, David Brito Zapata, María de Lourdes Torres, Carolina P. Reyes-Puig, Gabriela Pozo Andrade, Emilia Peñaherrera-Romero, Juan José Guadalupe López and Diego F. Cisneros-Heredia

n the Galapagos Islands, there are 13 species of endemic geckos. Except for the islands of San Cristóbal and Isabela, where two endemic gecko species reside, there is one endemic species per island in the rest of the archipelago. All endemic gecko species in Galapagos belong to the genus Phyllodactylus. However, four other species have been introduced to the islands, originating from Asia (the Common House Gecko Hemidactylus frenatus), Oceania (the Mourning Gecko Lepidodactylus lugubris), and continental Ecuador (the Coastal Leaf-toed Gecko Phyllodactylus reissii and the Western Diurnal Gecko Gonatodes caudiscutatus). These introduced species arrived as stowaways in food and supply shipments and have established themselves on the populated islands of the archipelago: San Cristóbal, Santa Cruz, Isabela, and Floreana. Two of them, the Common House Gecko and the Mourning Gecko, have become invasive species, spreading rapidly and in large numbers in populated areas. These invasive species have already had strong negative impacts on endemic gecko populations on other islands around the world, so it is imperative to understand the situation in Galapagos and take measures to conserve the unique species of the archipelago.



Since 2017, we have conducted research to learn more about the biology of endemic and introduced gecko species in Galapagos. To do this, we have collected data on where they live on the islands and within natural, agricultural, and urban ecosystems, what patterns of activities they develop, the characteristics of their anatomy, how they adapt to humanmade structures, what parasites affect their health, and their genetic diversity. In addition to biological studies, we have conducted analyses of the perceptions that exist on the islands about geckos to explore the social and cultural relationships that people have with these reptiles, for which we have developed informal interviews and participatory observations.

So far, the results of our research suggest that the impacts produced by

introduced species include competition for space and food, disease transmission, and predation, which could be exacerbated by the increase in invasive vegetation and facilitated by the expansion of constructions created by humans in which invasive geckos move much faster and more easily than endemic ones. Currently, endemic geckos have been displaced from virtually all urban and rural areas of the archipelago. However, their populations appear to still be healthy in areas covered by natural habitats. Nevertheless, the presence of dense populations of introduced geckos in some remote tourist areas and the transmission of parasites between different gecko species constitute an urgent call to attention about the imminent risk of extinction weighing on endemic geckos if the impacts of introduced species are not controlled.

The "Snakes and geckos of San Cristóbal and Isabela, Galapagos Islands" is led by GSC researcher and professor Diego Cisneros, Director of the Laboratorio de Zoología Terrestre del Instituto de Biodiversidad Tropical (IBIOTROP) from Universidad San Francisco de Quito (USFQ).

S ALLAS

This project is carried out by a research team formed by professor and students: Mateo Dávila Játiva, David Brito Zapata, Carolina P. Reyes Puig, and Emilia Peñaherrera Romero from Universidad San Francisco de Quito (USFQ), Colegio de Ciencias Biológicas y Ambientales, Instituto de Biodiversidad Tropical iBIOTROP, Laboratorio de Zoología Terrestre, Quito.

Other members of the team are: professor and GSC researcher María de Lourdes Torres, and students Gabriela Pozo Andrade and Juan José Guadalupe López from Universidad San Francisco de Quito (USFQ), Colegio de Ciencias Biológicas y Ambientales, Laboratorio de Biotecnología Vegetal, Campus Cumbayá, Quito, Ecuador. Community and Human Health **2**

Learning at the service of society: When the benefit is bilateral

Author: Luciana Lucero

ommunity outreach projects seek to contribute to resolving an environmental problem, benefiting both the community involved and the personnel who carry it out. Here we have two examples of projects developed by Universidad San Francisco de Quito (USFQ) with the active participation of students from the Galapagos campus. The first project, titled "Conservation of Galapagos pinnipeds through environmental education" was developed from June 2022 to January 2023 within the Student Park Ranger Program of the Galapagos National Park Directorate (GNP) sponsored by the Galapagos Conservancy and GSC. Thirty-nine

high school students from 14 to 17 years old from San Cristóbal Island participated in workshops, forums, and field trips to increase their knowledge about these species and develop critical thinking and problem-solving skills.

"Before I didn't know much about sea lions, but I loved learning to identify them by gender, size, and age. I loved going on a trip and seeing places that I had not been able to go before, such as Isla Lobos. It was very nice to share with my classmates." Luciana Rosero, student at the Galapagos Naval High School.



The community outreach project titled "Conservation of Galapagos pinnipeds, through environmental education" is part of the research project "Assessment of the population status of the Galapagos sea lion and fur seal. and its incidence in terms of management and conservation" led by Marjorie Riofrío-Lazo and Diego Páez-Rosas, both professors and researchers at USFO and GSC. and is supported by funds from USFQ and the Galapagos Conservancy. This project was developed within the framework of the Student Park Ranger Participation Program, executed by the Galapagos National Park Directorate. The project technician Wilson Andrade, and students Doménica Guerrero. Tania Tipán, Xavier Quijije, Dagfin Sotomayor, and Andrés Moreira also participated in this outreach project.

"During my participation in this program, what I learned the most is about the importance of conserving the sea lion and here I would like to emphasize that it suffers threats from the local inhabitants." Gabriel Córdova, student at the Galapagos Naval High School.

Various USFQ final-year students of the Environmental Management career executed the activities under the coordination of the project leader and with the support of the GNP. The evaluation of the levels of satisfaction and learning of the participants was carried out as the degree work of one of the executing students. The results indicated that the project managed to increase the beneficiaries' environmental awareness about protecting the sea lion and its marine-coastal habitat.



The community outreach project titled "Promoting good environmental practices in economic sectors of San Cristóbal Island, Galapagos" was led by Marjorie Riofrío-Lazo, professor of the **Environmental Management** course at the Galapagos campus and researcher at USFQ and GSC. The students Anaís Suntaxi, Diana Moreta, Génesis Rivas. Julissa Galarza. Kamila Zapata, Tobías **Castro and Zayra Echeverria** participated in this project.

"In the workshops that we gave to the students, we teach them to brainstorm ideas to create a project, we teach them the field methodologies, and they develop skills to find solutions to the environmental problems that we all face." Wilson Andrade, alumni of the Environmental Management program of USFQ Galapagos.

Another project titled "Promoting good environmental practices in economic sectors of San Cristóbal Island, Galapagos" was developed by students of USFQ's Environmental Management course in October 2022. The course applied the service-learning methodology, where students use academic content and tools in response to the needs of a community. The students trained business owners from seven economic sectors on existing environmental management tools and good practices to improve their daily activities and productivity. All of the participants described the experience as satisfactory and enriching and expressed greater environmental awareness. The beneficiaries were grateful to be included in the project. The students reaffirmed their social commitment and improved their leadership, communication, and problem-solving skills.

"In this project each of the students focused on a productive sector: tourism, agriculture and small commercial businesses. I did my project with a town store. What we had to do was teach the participants how to apply environmental practices in their business. For this, I gave them some graphic designs that they could paste in their stores with key messages for their clients, for example, the public was encouraged to bring cloth bags to avoid the use of plastic bags, or the importance of changing light bulbs to reduce the carbon footprint." Diana Moreta, Alumni of Environmental Management career at USFQ Galapagos.



8.

Burdens of paradise

A broad study looking at food and water insecurity in the Galapagos brings together a team of researchers to focus on an often-overlooked population.

Author: Andrew Russell

midst a blanket of fog, Josh Miller looks over the lip of Laguna a El Junco, a 270-meterwide wide freshwater lake nestled in the crater of an extinct volcano on San Cristóbal island in the Galapagos Archipelago. Below, Frigatebirds splash in the water, preening their feathers in one of the only freshwater sources on the islands. Miller squats down to get a water sample for his research.

"Before I was even at UNC, I didn't know that people lived on the Galapagos," Miller says. "I was really shocked to learn how many people live here, the prevalence of water and food issues, and how much that aligned with my research interests." Miller's research is part of a broader study run by biological anthropologist Amanda Thompson through the Galapagos Science Center (GSC). It represents a collaboration between researchers from UNC-Chapel Hill and Universidad San Francisco de Quito (USFQ), looking at how water and food insecurity on the islands have impacted health outcomes. Thompson believes it may have implications for other island communities.

"What Darwin termed the Galapagos in his journals when he first saw it was 'a little world within itself,' and I think that's true," says Thompson. "What we're seeing here is a microcosm of what we're seeing in other places. So the lessons that we learn here, we can then apply to other contexts, which might be a little bit more challenging to measure."



Beginnings

She first encountered Puerto Baquerizo Moreno while working on a research project on how birth affects health outcomes in China. At the time, her graduate student, Kelly Houck, was studying water quality and gut health in children in San Cristóbal. She invited Thompson to collaborate on a small pilot project with the town's residents. Later, Thompson went on to conduct a study looking at birth practices and child health in the Galapagos . That's when she started to get a picture of food and water insecurity on the islands.

"We were in the homes of families, and mothers were telling us how they were concerned about the quality of food or water their children had to eat and drink," Thompson says. "So we started this project in collaboration with USFQ and the hospital to measure access to water and healthy diets." The researchers initially understood these issues to be a result of the dual burden of disease. Common in low and middle-income countries, people struggling with the dual burden of disease have high levels of infection or undernutrition alongside high incidences of chronic conditions like obesity.

"Part of the reason you see that is that people's diets tend to change faster than infrastructure and water quality, particularly in places like the Galapagos, where you see uneven economic development," says Thompson. "You see healthy food like fresh fruits and vegetables become too expensive and at the same time people being able to afford things like packaged foods. Together, those changes lead to higher rates of obesity." Thompson says many low and middleincome countries over the past 20 to 30 years have experienced that shift.

For decades, farming and fishing were the primary industries in the Galapagos. In 1959, when the Galapagos National Park was established, 96% of the land on the islands was designated for the park, limiting farming activities throughout the archipelago and jump-starting the nascent tourist industry. Tourism started gaining speed in the mid-1980s and exploded in the early 2000s, shifting the economy away from fishing and farming.

"There's always been some reliance on food shipped in on barges from the mainland, but that increased with the increasing shift from agriculture to tourism-related industries," says Thompson. "As more tourists arrive, you see more people moving here to answer the demand of the tourism industry. That increases the need for the food on the island as well as dependence on food from the mainland."

Triple burden of ill health

Thompson's study found that about 70% of adults in the Galapagos suffer from obesity, which is the highest in Ecuador and among the highest in the world compared to similar populations. At the same time, many study participants also experienced gastrointestinal infections, urinary tract infections, respiratory infections, or other chronic conditions like iron deficiency, typifying the dual burden of disease researchers expected.

"What we concluded is that the Galapagos actually suffers from a triple burden of ill health," says Thompson. "That is, many individuals and households are simultaneously experiencing infectious diseases, chronic diseases like obesity and hypertension and diabetes, and high levels of distress."

Researchers continue to survey dietary quality and chronic disease risk and collect basic indicators like height and weight. They also measure things like



glucose, hemoglobin, and body fat, all to build a comprehensive picture of people's health on the islands.

They collect water samples from the houses they visit, drawn from both the kitchen sink and the backyard cistern. They test samples for contamination and determine whether it's environmental contamination or a marker of potential fecal contamination.

"On San Cristóbal, we have natural freshwater sources and a water treatment plant. It's the only island with freshwater," says Thompson. "Previous work by UNC researchers Jill Stewart and Valeria Ochoa and some of our other colleagues showed that the water was clean when it came out of the water treatment plant, but it's not necessarily clean when it comes out of people's tap. So we're interested in water distribution."

Water is life

That's where Miller and researchers like him come in. He's studied water issues in numerous low- and middleincome countries and has seen firsthand how water insecurity wreaks havoc with the health of a population.

"In every place I have studied, I have heard it multiple times in multiple different languages that 'water is life' – water truly undergirds everything that we do," says Miller.

Miller shares that in the Galapagos, availability is only one of several water issues. People often navigate problems with poor water reliability and quality. It's a reality Miller has seen during his time on the island.



"Many households know that the water isn't necessarily safe to drink, so they purchase bottled water, yet they might still cook with tap water, or bathe with it, so we see these skin rashes or other health outcomes related to poor quality. When issues with availability and quality co-occur in the same household, folks are much worse off."

Some people who experience water insecurity in the Galapagos tap into an "unseen" system for borrowing water, according to Miller. He witnessed similar methods for coping with water problems in communities in Kenya. People are trying to think through how to value and manage water in a way that's just and equitable but also helps people conserve it.

"If you run out of water, or you don't have enough clean water, you might go ask your neighbor to borrow water in the same way that I go ask my neighbor for a cup of sugar," he says. Much of Millers' work is done in tandem with the Puerto Baquerizo Moreno government. When he and his team travel to residents' homes to test the water, they are often accompanied by an official from the municipality. Miller is hopeful that his data will help.

"We have the mayor's office and municipality involved so that hopefully the findings we are generating don't just stay in a lab or some stuffy scientific publication, but are being implemented at the policy level."

He's grateful to see his research tied to that kind of engagement with the people of the Galapagos.

"What I really like about working here is that there is a real sense of community and giving back to the community," says Miller. "I really appreciate that because sometimes science can operate in a vacuum. But here, people are actually trying to make a meaningful difference."

In the same spirit of collaboration, Thompson is eager to take the data she's gathered from the Galapagos to other island populations. She's curious to see if the archipelago's isolation and tightly connected communities make them unique among island populations or a model to track larger trends.

"Are the health challenges that we're seeing here in my research similar to what you see in some places like Fiji, which has a much higher population but also has a huge tourism industry? What about someplace like Vanuatu across the Pacific or across islands more generally?" she asks. "I'm really interested in seeing if we see these associations between food and water and this triple burden of disease in other areas not as easy to measure but facing similar challenges."





Amanda Thompson is the codirector of the UNC Center for Galapagos Studies and the Galapagos Science Center. She is chair of and a professor in the Department of Anthropology within the UNC College of Arts and Sciences, a professor in the Department of Nutrition within the UNC Gillings School of Global Public Health, and a fellow within the Carolina Population Center.

Josh Miller is a PhD Student in the Department of Nutrition with the UNC Gillings School of Global Public Health and a member of the Human Biology Lab.

Also included on Thompson's research team are Jill Stewart and Peggy Bentley from UNC-Chapel Hill and Enrique Teran, Valeria Ochoa, and Jaime Ocampo from USFQ.



The Connecting With Nature Program has successfully integrated the Galapagos community into environmental conservation for the fourth consecutive year

Authors: Victoria Castro, Molly Herring and Karina Vivanco

Through its community outreach programs, the Galapagos Science Center (GSC) contributes to the sustainable development and the generation of greater environmental awareness in the local community. Much of this success is due to the hard work and dedication of Leidy Apolo, GSC's community outreach coordinator, as she has developed and implemented the Connecting with Nature Program (PCCN).

Under Leidy's leadership, the 2022 fourth phase of the PCCN has managed to impact more than 2,500 community members. This includes the participation of 799 children in activities, as well as 14 teachers from schools and colleges. In addition, the PCCN received support from 36 local students from USFQ Galapagos and 21 local, national, and foreign teachers, researchers, and experts. As a result, the PCCN has directly benefited more than 6,500 people throughout its 4 stages (2019 - 2022).

In this interview, Leidy shares her passion for helping communities in Galapagos stay connected and generate social consciousness.



What brought you to the GSC?

I originally worked in other outreach projects on San Cristóbal, but came to the GSC because there are many research projects happening here that are beneficial for the islands, but at the same time are not as well-known by people in the community. I have focused much of my role on teaching communities, specifically groups of children and adults, or even a mix of ages who participate in the same activity. We are constantly looking for strategies to reach people and achieve the great objective - to increase interest in science and research, and improve conservation values in our community.

What is unique about how the GSC engages with the community?

We are doing activities in different methodologies and spaces. We are in schools, but we are also on the beach or the boardwalk or the park. We are working with children but also with families and people of all ages. In other words, we get closer to people and make them part of a social or environmental problem that occurs on the islands, to think of possible solutions. If we want to have more local scientists, we have to bring people closer in various ways: through a talk, in a species observation outing, or in an event.



What is your favorite event to participate in?

Family Science events are definitely windows full of opportunities to share and learn. In these events, we might talk about sharks, birds, sea lions and other species. We always learn something new about their ecology, their threats, and above all, we remember the small actions that we can do for their conservation. The same happens with other topics such as climate change, agroecology, or gender. Each event is an opportunity to raise awareness about a problem, learn, and practice what we have learned.

What do you enjoy most about your position?

One of the best field trips I have had in my life as a student was for my Coral Reef Ecology class. We performed fieldwork for a weekend at JCU's Orpheus Island Research Station. The main activity was monitoring the state of the coral reefs around the island using different techniques for marine research.



Has your own family benefited from the GSC community and its programs?

Being a mother inspires me because I feel that through my work there will be children and young people like my daughters, who love, value, respect, and protect their environment and also invite other people their age, their friends, and classmates to do the same. It's what I try to teach them all the time – to share what they learn.

I would like to thank the USFQ and GSC staff who are constantly involved in the activities. The achievements are the result of everyone's efforts.



The Connecting with Nature Program seeks to promote responsibility in the conservation of natural resources in the Galapagos Islands. During its fourth phase, educational and experiential activities were carried out to raise awareness about the importance of protecting the environment and promoting sustainable practices, especially for the local community, children, and youth. The program has had the participation of thousands of people, including students, teachers, community participants, and local and international collaborators. Despite facing challenges, including regaining its audience after the COVID-19 pandemic, the program has successfully executed numerous activities and is crucial to the conservation of natural resources in the Galapagos Islands.







Author: Silvia Zavala

Thanks to partnerships with the Galapagos National Park Directorate (GNP) and other local public institutions, the GSC has expanded its operations to host interdisciplinary research projects. 'Flagship projects' have been strategically selected to provide hands-on learning experiences for local and international students. This unique opportunity to gain experience in practical and applied research processes is offered through our Experiential Education Program.

Who is it for?

The options are aimed at USFQ students in Galapagos as well as national and international students from other universities.

What options are available?



Join Program Science!:

An Experiential Education Program, aimed exclusively at USFQ Galapagos students, whose main objective is focused on inspiring the next generation of Galapagos scientists. It offers a unique opportunity to gain practical and theoretical experience in different research areas, and to improve possibilities for establishing professional networks.



Learning Experiences:

This option is designed to give students the opportunity to work closely with researchers and experience active scientific research in Galapagos. Through hands-on experience, students will develop a realistic view of scientific inquiry, its demands, and the excitement of discovery.

The program can be completed through a variety of options, tailored to the particular needs of each student.



a) Junior Scientist

This option is for high school graduates who are interested in science and conservation, which may prepare them for university studies in related disciplines. It is designed to offer the experience of participating and experiencing active scientific research in Galapagos





b) Bachelor Scientist

This is an intensive option, tailored for visiting students from an international university who wish to participate at the GSC's selected Flagship Projects. Students accompany local researchers to experience scientific inquiries in areas of special interest.

c) Tailor Made Research Experience

This option has been designed to meet the different requirements of the many students applying for a research experience with the GSC. Participants will obtain a personalized program according to their interest and availability of time. This option is also aimed at professors from national or international universities who wish to offer one of their courses in the islands, whose main component is scientific research. Throughout these years we have involved 389 national and international students. Their contribution to research has been part of numerous scientific articles and publications.



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INSPIRATIONS

In this section we want to share the artistic works, learnings, and commitments inspired and created by the participants of our Family Science events.

The Connecting with Nature Program periodically offers Family Science events. It is a dynamic space whose main objective is to promote the interaction of local families, to encourage conservation through changing habits and lifestyle.

Since 2019 we have organized around 40 events where topics in the socio-environmental field have been discussed, such as: prevention of gender violence, implementation of organic agriculture, threats and resilience in the face of climate change, impact of pollution by plastic garbage, and the importance of biodiversity conservation, among others.



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