CINDAQ
Surfacing Vital Knowledge

2024

CINDAQ 2024 Annual Report

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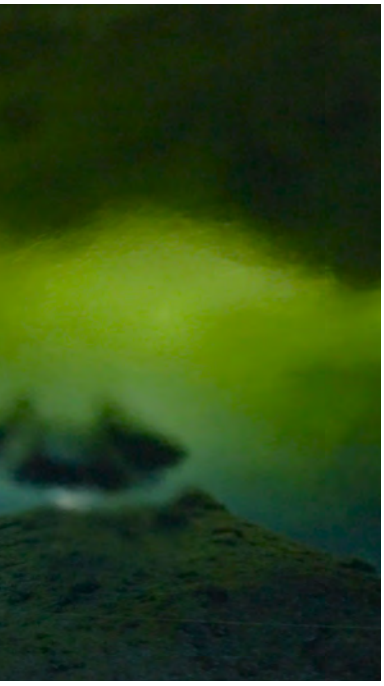
Facilitate **research**, promote **education** and support the **conservation**
of the natural and cultural resources associated
with the cenotes and underground rivers of Quintana Roo, México

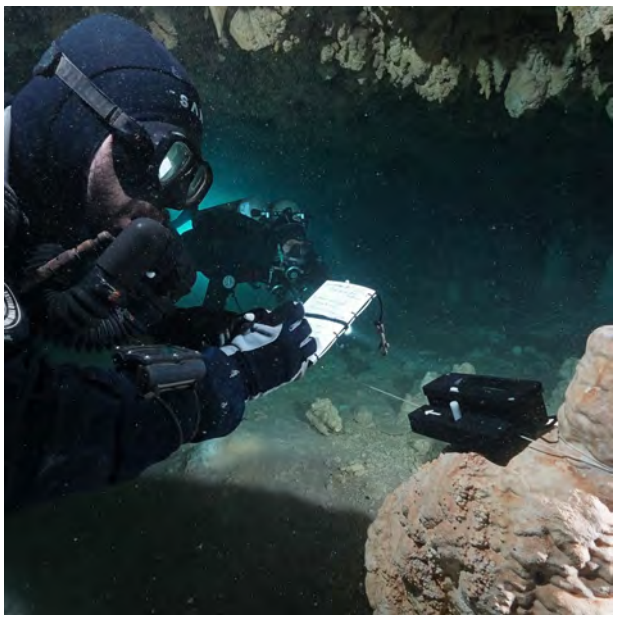
Explore

CINDAQ Annual Report for 2024

Content



EDITORIAL



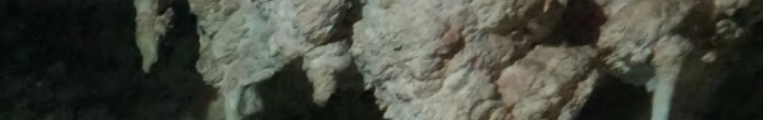
Surfacing vital knowledge

Leveraging exploration as a tool to generate usable data to better understand and protect our aquifer

2024 was yet another year of achievements for our team. In addition to completing projects close to home, we traveled to **eight countries** outside of Mexico, making an impact both above and below the water.

In **Ox Bel Ha**, we continued our efforts to resurvey, document, and further expand this vast system. By the end of the year, Ox Bel Ha's total confirmed length reached 524 km, solidifying its place among the **longest caves on Earth**. We have just over 40 km of cave left to revisit and resurvey, a goal we anticipate accomplishing in 2025. On the surface, we systematically installed camera traps and sound monitoring devices at key cenotes within Ox Bel Ha. The results continue to surprise us, confirming that the biodiversity of the Yucatán Peninsula's forests heavily depends on cenotes as vital water sources. As we like to say, extraordinary caves demand extraordinary effort, and Ox Bel Ha continues to be our teacher.

We returned to the **Sian Ka'an Biosphere Reserve**, building on our 2023 efforts in the mid-coast area of the reserve, based out of the Casa Blanca Fishing Lodge at Punta Pájaros. At Cenote Casa Blanca, we expanded on the exploration we began in 2023. Additionally, at a new ojo de agua (Poza Punta Pájaros), we discovered a siphon with large, ongoing passageways. At Cenote



Tuun Ja, we captured water chemistry profiles confirming low saltwater temperatures and filmed the main downstream area in high-quality video, illuminated by over 250,000 lumens of light. Having successfully tested our base camp infrastructure, we plan to return to Tuun Ja in early 2025 for our first long-term project. We remain convinced that a massive cave system awaits discovery in the northern half of the reserve.

We also began applying our methods of resurvey and documentation to other caves in the region, including **Sistemas Zapote-Camilo and Sac Actun**, deepening our understanding of biological patterns and sedimentation in the area's caves. With each dive, we continue to refine our techniques and methodologies for survey and documentation.

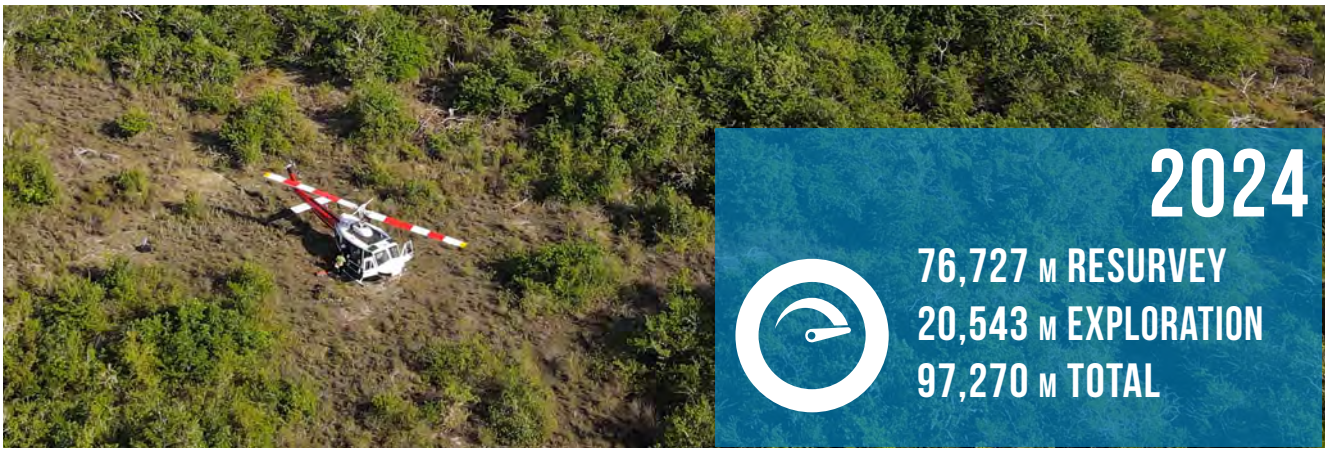
Together with our partners from the **National Institute of Anthropology and History** Underwater Subdirectorate (INAH-SAS), we presented a project to INAH's General Council aimed at expanding the work already completed in Hoyo Negro and Sagitario (La Mina). This project seeks to enhance our understanding of life in the Yucatán Peninsula during the last Ice Age and the crucial role caves and cenotes played. In 2025, we plan to begin the first phases of this multiyear effort. In the fall, with direction and support from INAH-SAS, we recovered three hammerstones from Sagitario (La Mina). These artifacts will be analyzed before being displayed at the new INAH museum in Tulum. Their recovery marks the completion of a full cycle - from discovery and research to publication and public outreach - educating thousands of locals and visitors to the region.

In the office, we expanded our **Network Attached Storage (NAS)** system and added a dedicated workstation capable of **automating tasks** like photogrammetry and GIS processes. The efficiency of cave survey data processing has drastically improved. What used to take 40 minutes and involve multiple steps to get data from a Mnemo into our GIS now is done in a matter of minutes and with a couple of clicks. We now have a solid foundation upon which we can continue to build.

Internationally, we participated in the ADEX conference in **Singapore** and assisted with cave surveys on Muna Island in **Indonesia**. We also provided expertise in **Sardinia**, **the Bahamas**, **India**, the **United States**, and **Belize**, advising partner organizations on data management and GIS strategies. In 2024, we applied our expertise both above and below the surface at **three UNESCO World Heritage sites**: La Isabela (Dominican Republic), Sian Ka'an Biosphere Reserve (Mexico), and Chichén Itzá (Mexico). As an accredited NGO for the 2001 Convention on Underwater Cultural Heritage, we remain committed to collaborating with sister organizations worldwide to uphold the convention.

We also continued to develop and nurture relationships with like-minded NGOs, institutions, donors, and sponsor organizations. Together, we can grow, learn, and expand our efforts here in Mexico and globally. We are, as always, **deeply grateful for the support we receive**.

As we reflect on 2024 with pride, we eagerly anticipate all that 2025 will bring.

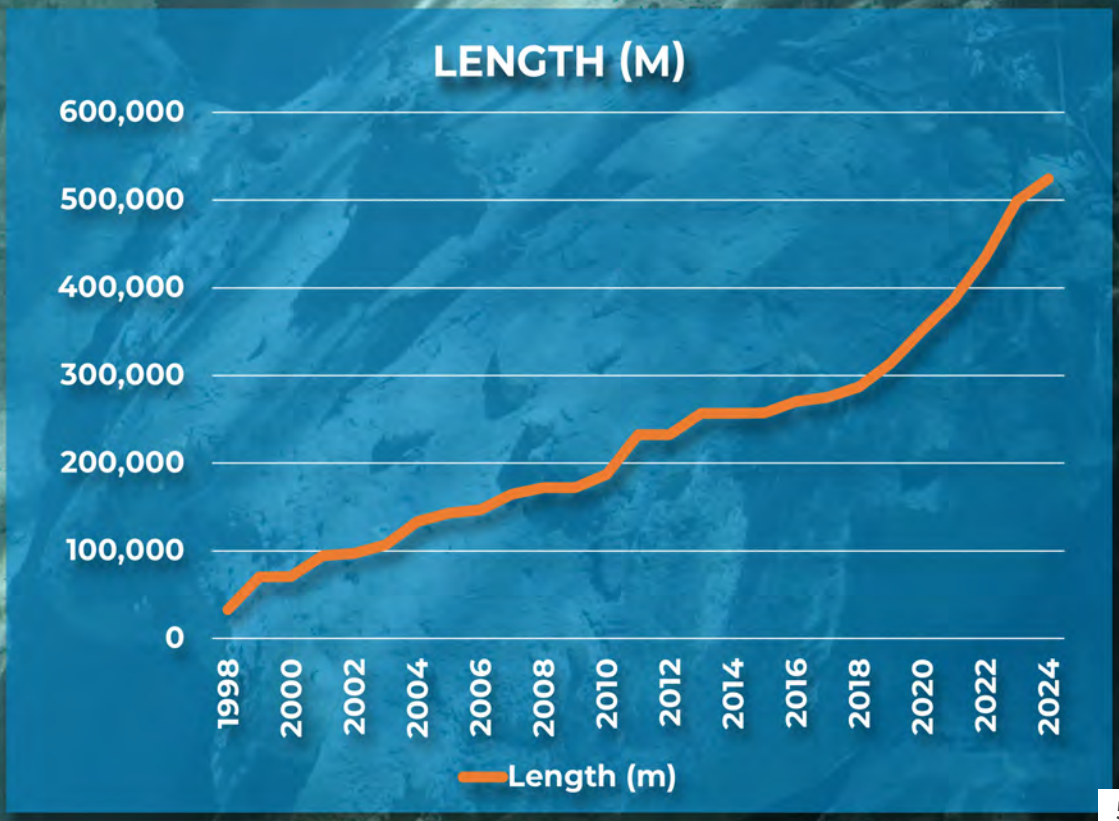


OX BEL HA

CONFIRMED DATA:	524,108 M
2024 RESURVEY:	27,969 M
2024 EXPLORATION:	12,507 M

CENOTES:	160+
SURFACE AREA:	69+ KM²
N-S DISTANCE:	12,000 M
E-W DISTANCE:	9,000 M
WIDEST PASSAGE:	120+ M
AVERAGE DEPTH:	12.8 M
DEEPEST DEPTH:	57.3 M
MAX. LOOP CLOSURE:	7,500 M

SURVEY STATIONS:	61,231
SECTIONS:	632
AVERAGE SHOT:	8.6 M
JUMPS:	2,500+
T INTERSECTIONS:	1,800+
ARROWS/MARKERS:	10,548



OX BEL HA - CINDAQ 2024

Ox Bel Ha remains a central focus for our team as the Tulum area continues to grow. With the inevitability of development comes the responsibility to create as permanent a record of the Ox Bel Ha system as possible.

Since we began resurveying Ox Bel Ha in 2018, the cave system's known size has **doubled**. Starting with approximately 245 km of data in 2018, we have since added nearly 175 km of new exploration and 305 km of resurveyed data—over 100 km of which was previously unrecorded. By the end of this year, we have just over 40 km of cave left to resurvey.

Given the measurable correlation between the amount of cave resurveyed and new exploration conducted, we fully expect Ox Bel Ha to continue growing—potentially surpassing 600 km in total surveyed length before our work is complete. In 2024, our efforts were concentrated around Cenotes Naach Wenen Ha, Perla, Canales Norte, Bevo, and Gemini 2.

An exceptional cave requires exceptional means. Ox Bel Ha has thus not only been the driving force behind the development of our data management system and GIS infrastructure to handle the amount of information yielded by such a huge cave, but it also led to the development of new methods for survey, photogrammetry and documentation. Thanks to the ongoing refinement of these essential platforms, we are now better equipped to **engage the scientific community**. Our observations can be graphically represented and directly linked to the raw data we collect, providing a more comprehensive understanding of the system.

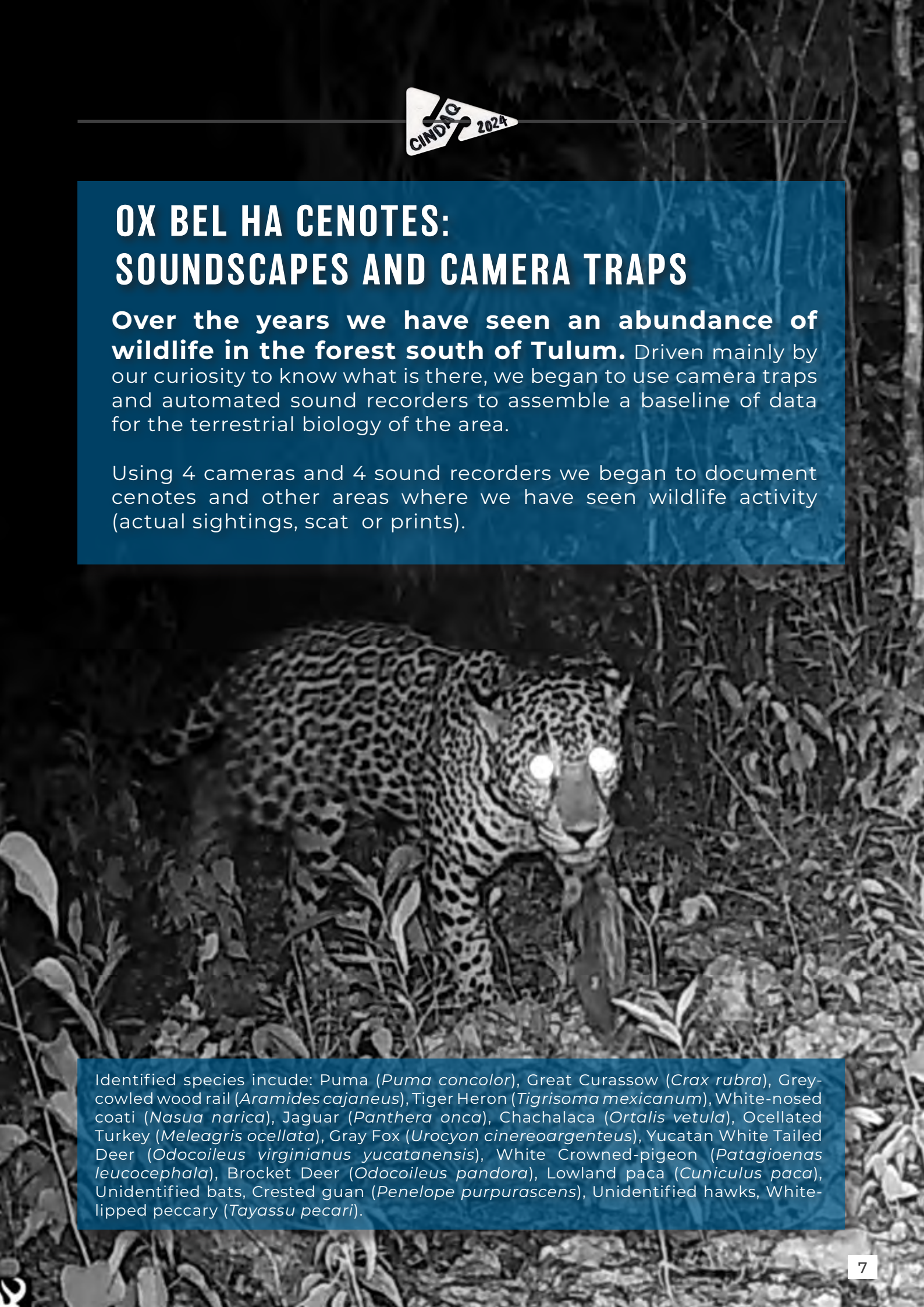
The rapid urban expansion of Tulum, coupled with the construction of the Tren Maya and the opening of the Tulum International Airport all make our work in this area even more pressing. Large parts of Ox Bel Ha are already beneath urbanized areas or areas slated to be developed, adding to **the sense of urgency for our continued efforts to map, document and better understand Ox Bel Ha**.

We are deeply grateful for the access granted by the Ejido José María Pino Suárez, which allows us to continue this critical work.

OX BEL HA CENOTES: SOUNDSCAPES AND CAMERA TRAPS

Over the years we have seen an abundance of wildlife in the forest south of Tulum. Driven mainly by our curiosity to know what is there, we began to use camera traps and automated sound recorders to assemble a baseline of data for the terrestrial biology of the area.

Using 4 cameras and 4 sound recorders we began to document cenotes and other areas where we have seen wildlife activity (actual sightings, scat or prints).

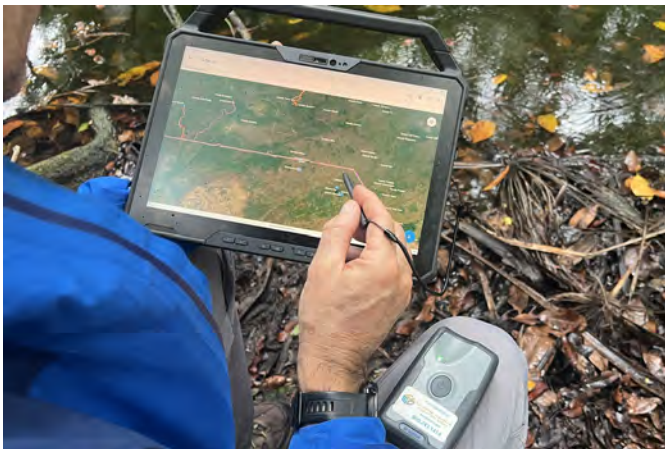


Identified species incude: Puma (*Puma concolor*), Great Curassow (*Crax rubra*), Grey-cowled wood rail (*Aramides cajaneus*), Tiger Heron (*Tigrisoma mexicanum*), White-nosed coati (*Nasua narica*), Jaguar (*Panthera onca*), Chachalaca (*Ortalis vetula*), Ocellated Turkey (*Meleagris ocellata*), Gray Fox (*Urocyon cinereoargenteus*), Yucatan White Tailed Deer (*Odocoileus virginianus yucatanensis*), White Crowned-pigeon (*Patagioenas leucocephala*), Brocket Deer (*Odocoileus pandora*), Lowland paca (*Cuniculus paca*), Unidentified bats, Crested guan (*Penelope purpurascens*), Unidentified hawks, White-lipped peccary (*Tayassu pecari*).



Installed camera traps were inspected every 4–8 weeks to ensure they were in good working order and correctly positioned. Memory cards and batteries were removed and replaced for each camera. Additionally, vegetation at the camera sites was cleared, including branches, leaves, and any other obstacles that could accidentally trigger the cameras or obstruct their field of view. This process ensures **clear and effective capture of images and videos**. Finally, each camera trap was georeferenced, allowing for spatial control of the installed cameras and facilitating data analysis related to wildlife distribution and environmental conditions.

Our new **Dell ruggedized laptops** enable us to download and reformat memory cards on-site and view the captured videos. The Wildlife Acoustic sound recorders, preprogrammed to record sound for two hours at dawn and dusk each day until the memory cards were full, **create soundscapes of each cenote**. These recordings can later be processed using analytical software to identify bird and amphibian species. Using GoProMax and Insta360 cameras, we created 360-degree images to document the entire site, including the positioning of cameras and recorders.



Additionally, with Drone Deploy, we captured 360-degree images above or as close to directly above the sites to provide a geographical context. At the very least, our goal has been to test the efficacy of the cameras and recorders in **creating a baseline of information on cenotes in their most pristine state**. If successful, we plan to expand the use of cameras to other sites across the region. Eventually, by using an online platform like Kuula, we can create an immersive, interactive experience that takes viewers on a journey through Ox Bel Ha. One thing is clear: there is an abundance of wildlife just south of Tulum, and their reliance on cenotes as watering holes is essential.

To see examples, follow these links: cindaq.org/bevo-360, cindaq.org/sonrisa-360.

THE SIAN KA'AN BIOSPHERE RESERVE

Over the course of the year we managed two trips down to Sian Ka'an, one to Punta Pájaros and another to Cenote Tuun Ja and the Muyil-Xamach Fire site. We also managed to finish acquiring and testing all the necessary gear for our future base camp at Cenote Tuun Ja.

Since 2006, CINDAQ has been exploring, documenting and helping to better understand the network of flooded caves beneath the Sian Ka'an Biosphere Reserve. Our core objectives in this area are simple: continue to expand our areas of exploration, and seek ways in which to overcome the significant challenges that Sian Ka'an presents as we do this. At this point in time, we have several 'windows' into the aquifer of Sian Ka'an stretching from the northern border down into Punta Pájaros. Each visit has allowed us to expand our understanding of the reserve. Each area provides us with another piece of a complex and intriguing puzzle. Put together, these puzzle pieces have helped us to begin to define what could potentially be an enormous cave system in the northern half of the reserve.

The remoteness of the reserve makes the logistics of diving extremely challenging, but we feel that our team, our resources and our experience are able to overcome these challenges and to continue to reveal what lies beneath Sian Ka'an.

SIAN KA'AN - PUNTA PAJAROS

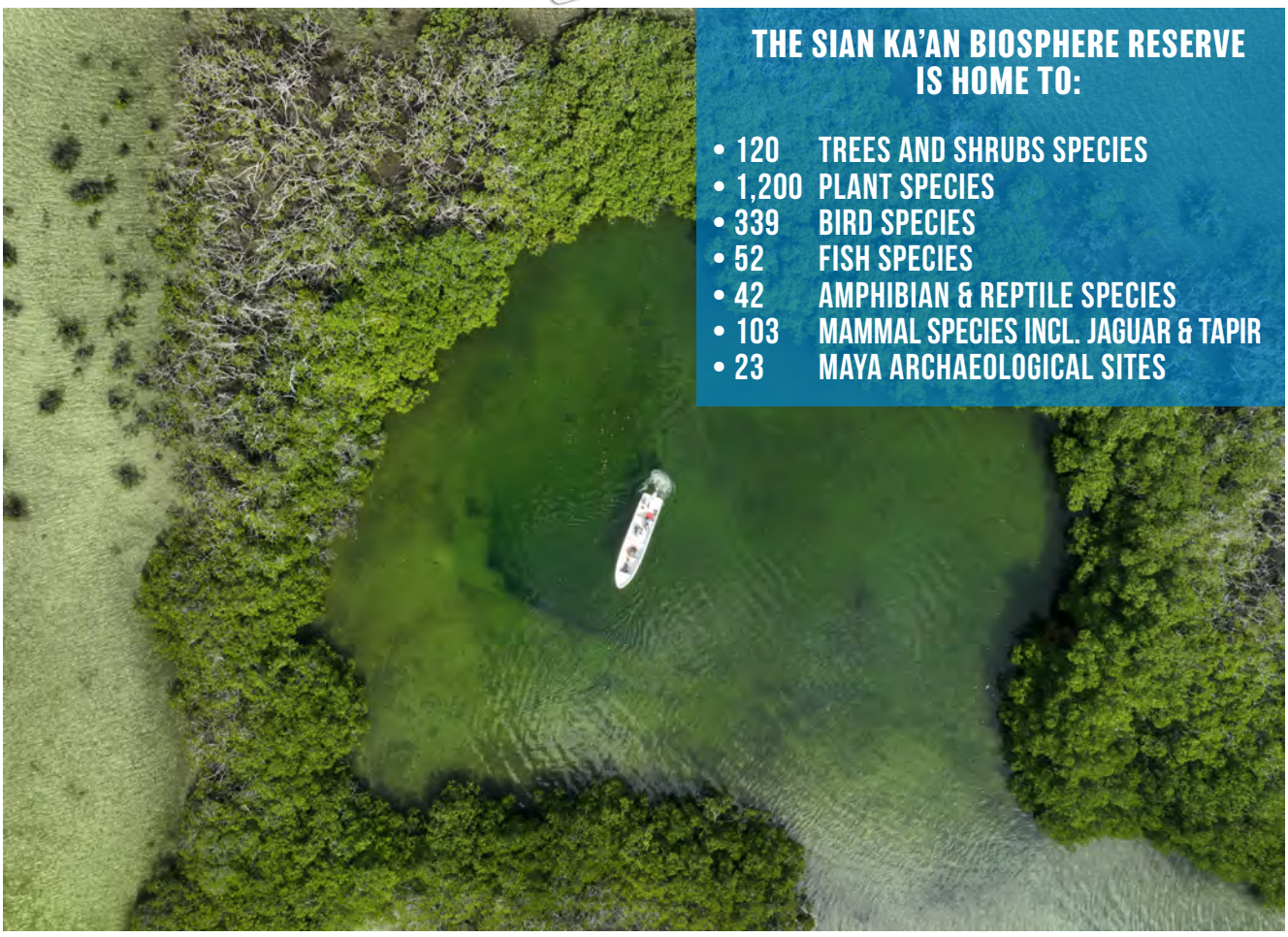
From September 14th to September 19th, at the invitation of the Casa Blanca Fishing Lodge and with permits from CONANP, we traveled to the remote island of Punta Pájaros and Bahía de Ascensión to investigate the presence of caves and assess their potential for exploration. Our objectives for this trip were as follows:

1. Locate and assess as many cave entrances as possible.
2. Based on the assessments, conduct exploratory dives to evaluate the potential for cave exploration in the area.
3. Document the area and its sites using drones and surface cameras.
4. Deliver a presentation to the guests and staff of the Playa Blanca and Casa Blanca Lodges.

During the trip, we located four new "ojo de agua" entrances in the mangroves and lagoons west of Punta Pájaros. Over four days of diving, we conducted five dives in two entrances: Cenote Casa Blanca and Poza Punta Pájaros. These dives resulted in 674 minutes of bottom time, during

which we explored and surveyed a total of 1,180 meters of new cave passageways. Additionally, we captured high-resolution video of the main cave passage in Cenote Casa Blanca. The findings from these dives have further reinforced our strong belief in the significant potential for cave exploration in this area.

We also continued capturing 360-degree panoramic images to enhance the virtual tour of the Punta Pájaros/Bahía

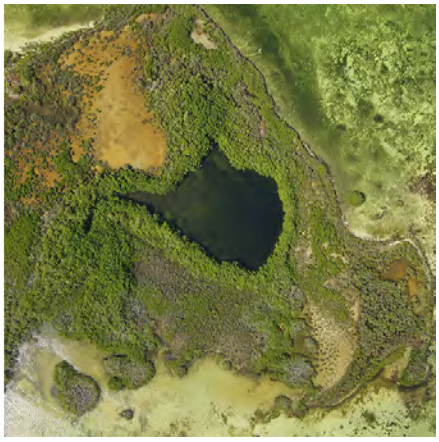


THE SIAN KA'AN BIOSPHERE RESERVE IS HOME TO:

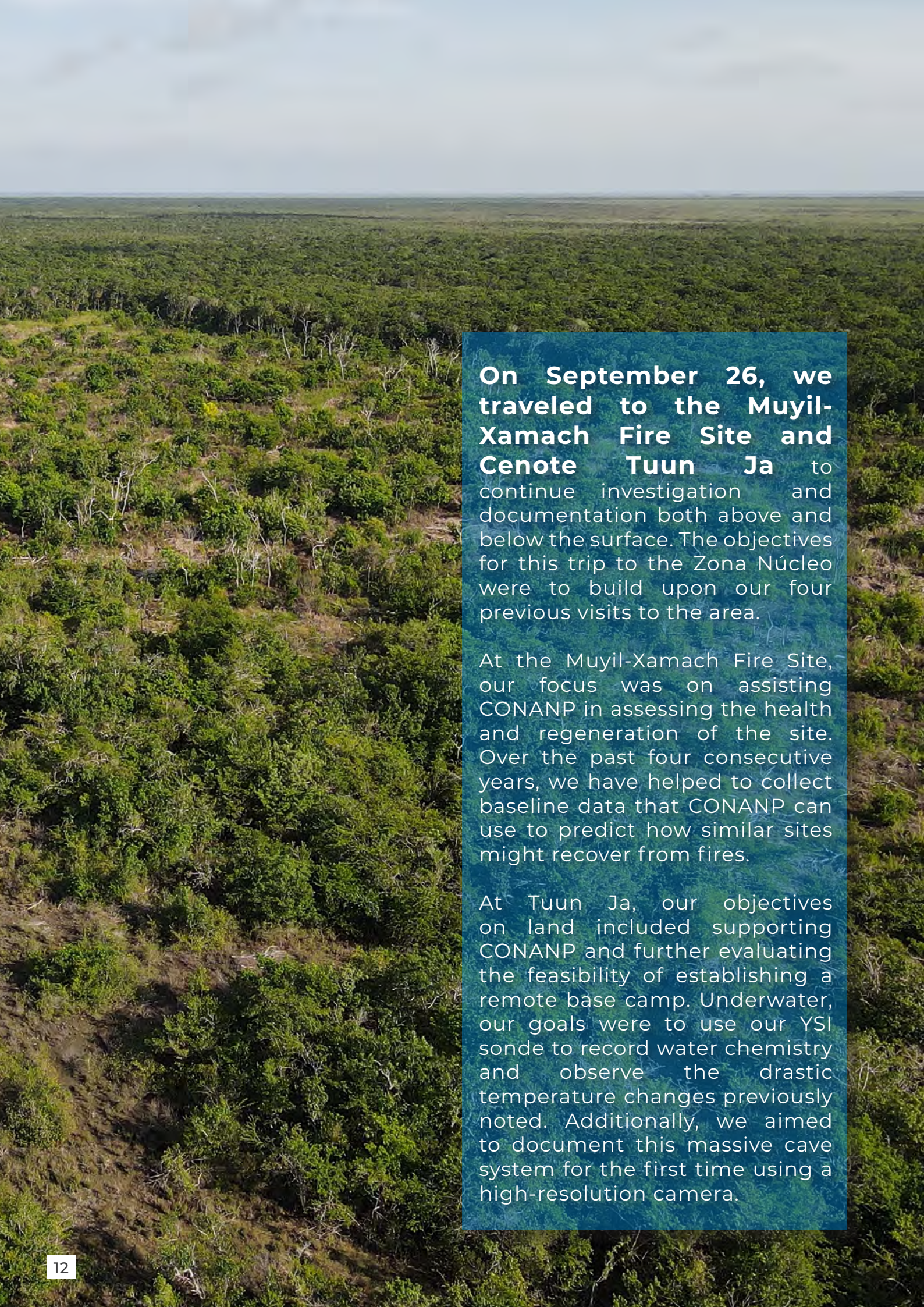
- 120 TREES AND SHRUBS SPECIES
- 1,200 PLANT SPECIES
- 339 BIRD SPECIES
- 52 FISH SPECIES
- 42 AMPHIBIAN & REPTILE SPECIES
- 103 MAMMAL SPECIES INCL. JAGUAR & TAPIR
- 23 MAYA ARCHAEOLOGICAL SITES

de Ascensión region. Using our Mavic 2 drone with DroneDeploy software, we obtained additional panoramic aerial images, while on the ground, we utilized the Insta360 RS to capture immersive visuals. The virtual tours we create using these panoramic images have proven invaluable in providing a clearer understanding of the area, both for us and others. In the case of Punta Pájaros, they also serve as an excellent resource for visitors to explore the landscape remotely. A compilation of the 360-degree photos associated with this area of the reserve can be viewed at *cindaq.org/punta-pajaros-360*.

During our stay, we gave two presentations to the guests and staff. Sam shared details about CINDAQ's work in the region and explained the purpose of our visit to Punta Pájaros in the broader context of our efforts in Sian Ka'an. As firm believers in the importance of sharing the knowledge we have gathered over the years, we were thrilled by the warm reception and the many insightful questions posed by guests and staff.



SIAN KA'AN - MUYIL-XAMACH & TUUN JA



On September 26, we traveled to the Muyil-Xamach Fire Site and Cenote Tuun Ja to continue investigation and documentation both above and below the surface. The objectives for this trip to the Zona Núcleo were to build upon our four previous visits to the area.

At the Muyil-Xamach Fire Site, our focus was on assisting CONANP in assessing the health and regeneration of the site. Over the past four consecutive years, we have helped to collect baseline data that CONANP can use to predict how similar sites might recover from fires.

At Tuun Ja, our objectives on land included supporting CONANP and further evaluating the feasibility of establishing a remote base camp. Underwater, our goals were to use our YSI sonde to record water chemistry and observe the drastic temperature changes previously noted. Additionally, we aimed to document this massive cave system for the first time using a high-resolution camera.

SIAN KA'AN - MUYIL-XAMACH & TUUN JA (CONT.)

Thanks to the DroneDeploy platform and our new Insta360 RS camera, we were able to efficiently capture high-quality images. Using our Dell Latitude Rugged computers and Starlink, powered by an EcoFlow battery, we were, for the first time, able to **upload photos directly from the field to DroneDeploy for processing**. The processed images were sent back to us while we were still in the field.

A compilation of 360-degree photos associated with this area of the reserve can be viewed at cindaq.org/zonanucleo-360. As always, we are deeply grateful for the ongoing support from DroneDeploy, EcoFlow, and Dell.

This was our second dive into the downstream of Cenote Tuun Ja after the initial dive in October, 2021. The objectives for this dive were twofold: **collect water chemistry data with the YSI data sonde, and document the cave using a high resolution video camera**.

The YSI data sonde was used to collect a horizontal profile of the water column from the surface to a maximum depth of 28 m, as well as two vertical profiles along the way. The YSI collects water chemistry data on pH, conductivity, dissolved oxygen, and turbidity in addition to depth and temperature. These data will provide a baseline for future projects in Cenote Tuun Ja, and a comparative dataset for the rest of the area of Sian Ka'an and the region.

A preliminary analysis of the data provided by Dr. Eduard Reinhardt of McMaster University found the water masses to have unusual profiles. Of note was the

CAMERA TRAPS: IDENTIFIED SPECIES ON CAPTURED IMAGES

- PUMA (PUMA CONCOLOR)
- GREY-COWLED WOOD RAIL (ARAMIDES CAJANEUS)
- CENTRAL AMERICAN TAPIR (TAPIRUS BAIRDII)
- CHACHALACA (ORTALIS VETULA)
- GRAY FOX (UROCYON CINEREOARGENTEUS)
- WHITECROWNED-PIGEON (PATAGIOENAS LEUCOCEPHALA)
- LOWLAND PACA (CUNICULUS PACA)
- CRESTED GUAN (PENELOPE PURPURASCENS)
- WHITE-NOSED COATI (NASUA NARICA)
- GREAT CURASSOW (CRAX RUBRA)
- TIGER HERON (TIGRISOMA MEXICANUM)

temperature profile for Tuun Ja **showing cooler temperatures with increased salinity** which is the opposite of what is normally found and the depth of the halocline which is about 4m deeper than expected for its position relative to the coast.

We filmed from the furthest point of penetration downstream (469 m) all the way back to the entrance of Cenote Tuun Ja. A total of **280,000 lumens of light was brought into the cave** in order to attempt to help us capture its size. In the deeper sections which are more defined tunnels, the lights were able to adequately light the passageway. Filming in the shallower passageways was more challenging as they are much larger and enveloped by a darker red tannin layer which thus swallowed more light. Nevertheless, we were able to capture some incredible images of the cave revealing its scale and beauty for the first time ever.

At both sites, **previously installed camera traps were inspected** to ensure they were in good working order and correctly positioned. Memory cards and batteries were then removed and replaced for each of the cameras. In addition, vegetation was cleared at the camera sites, removing branches, leaves and any other obstacles that could obstruct the camera traps field of view. This ensures clear and effective capture of images and videos. Finally, each camera trap was georeferenced, which allows spatial control of the installed cameras and facilitates data analysis in relation to wildlife distribution and environmental conditions. The memory cards were downloaded at the **CONANP** office and reviewed. One camera showed signs of water damage and was replaced with a new one. As seen in the previous year, **the biodiversity of this remote area is abundant**.

SIAN KA'AN - BASE CAMP PREPARATION

With **our growing interest in remote areas of the Sian Ka'an Biosphere Reserve** and beyond, we have spent the last four years assembling equipment to support extended **stays far from civilization**. Our focus has been on eight key areas: workstations, power, communication, waste management, food and water, safety, sleeping arrangements and diving logistics.

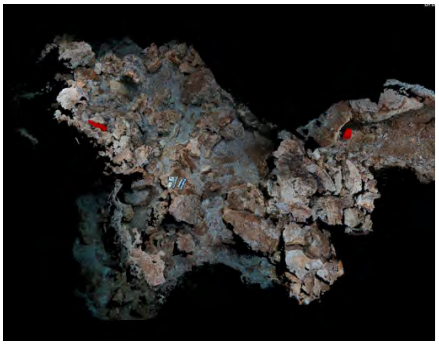
The goal is to establish an infrastructure that enables us to work comfortably and **with minimal environmental impact**. The ultimate test will be at Cenote Tuun Ja, accessible only by helicopter. In 2024, we field-tested most of the equipment in more accessible locations. With help from longtime friend **Pepe Sanchez**, we assembled the setup in Sam's backyard before testing it overnight in the Ox Bel Ha area near Cenote Gemini.

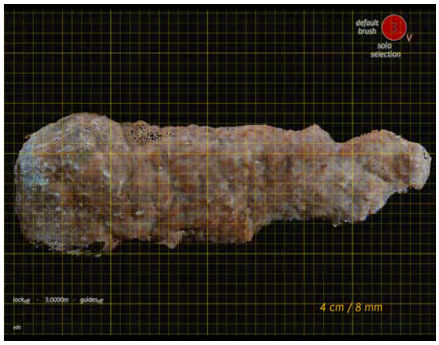
SAGITARIO - HAMMERSTONE RECOVERY

With the construction of a new **INAH Museo Regional de la Costa Oriental in Tulum**, we were approached by **Helena Barba Meinecke of INAH's Underwater Archaeology Sub-Directorate** with the idea of recovering artifacts from Sagitario La Mina to exhibit in the museum. This official request superseded the need for a permit from the Consejo de Arqueología, which is usually required for any archaeological collection.

The prospect of displaying tangible objects from La Mina that could help the general public relate not only to the site but also to the broader context of human activity during the last ice age in this region was very appealing to us.

INAH specifically requested hammerstones, the only shaped artifacts yet found from Paleoindian-era sites in Quintana Roo. We consulted with La Mina project archaeologist **Dr. Jim Chatters and the INAH-SAS team** regarding the selection process.





The specimens were chosen based on three criteria:

- **1 - Obvious crushing** of end surfaces due to battering
- **2 - Location** atop large, distinct piles of mine spoil, confirming their association with mining activity
- **3 - A reddened appearance** on the sides, likely caused by ochre smeared on by the miners' hands.

This final criterion was included with the hope of finding fingerprints or at least distinct finger marks on the stones.

Three specimens were collected from the most intensively mined portion of La Mina, including a very large stalagmite apex heavily battered on both ends, a large stalagmite midsection with battering on one end, and a smaller stalagmite section with bright red coloring.

Using the framework from the Hoyo Negro project, we created **photogrammetric models** not only to document potential hammerstones but also to **extract exact measurements** of the selected objects. This allowed us to fabricate protective vessels for their safe extraction.

Sam, Fred, and Chris collected these specimens on September 4, with Dr. Chatters and the INAH team with Helena Barba Meinecke and Gabriel Leon serving as archaeological supervisors and surface support. The artifacts were placed into large plastic ziplock bags, which remained sealed until they were opened for a brief inspection at the museum. Fred filmed the collection process.

The artifacts were briefly inspected through the clear plastic immediately after surfacing and were taken directly to the museum.

The collected specimens were subsequently transported to Campeche for study. These studies will follow a protocol developed for SAS-INAH by Dr. Chatters and will include **3-D modeling, weighing, measuring, and analysis using a portable X-ray diffractometer**.

Once dry, the artifacts will be inspected for fingerprints, photographed in detail, and the pigments on their surfaces will be sampled. These samples will undergo additional geochemical analyses to fingerprint the ochre found on each specimen.

After the studies are completed, the artifacts will be installed in Sala 1, the Pleistocene and underwater section of the Museo Costa Oriental.

> “To help the general public relate not only to the site but also to the human activity during the last ice age in this region”

UCSD/SCRIPPS: CAVE SCANNING

CINDAQ is collaborating with **Loren Clark, Scott McAvoy, and Dominique Rissolo** from **UC San Diego and the Scripps Center for Marine Archaeology (SCMA)** on a project investigating human and faunal access to caves during the Late Pleistocene and Early Holocene. This non-invasive project examines the morphology of cave entrances and passages, comparing these physical constraints with the morphologies of megafauna known to have entered and moved through caves. Additionally, a detailed understanding of the physical challenges and opportunities navigated by Paleoamericans (who extensively used caves) can provide valuable insights into ancient human behavior and decision-making in these dark and complex environments.

The size and shape of cave passages not only restricted or facilitated access by humans and animals, but rising sea levels after the end of the Last Glacial Maximum introduced a fourth dimension to consider. CINDAQ has been systematically **collecting data that enables the science team to produce "heat maps" of access** based on animal size and the degree of human determination. The team at UC San Diego is particularly interested in cave entrances, recognizing that these environments are dynamic and subject to a range of speleogenic processes over time. The first phase of this study involves **thoroughly documenting entrance geometries in 3D**.

In August, CINDAQ coordinated an intensive scanning campaign with Loren and Dominique. Together, they scanned the entrances to La Mina, including Pu'bix, Kilix Pach-Och, and the Sagitario entrance complex. As part of the Sac Actun Cave System, they also scanned the White River, Concha, and Fenómeno entrances, and, along with Beto Nava, Ich Balam and the newly surveyed entrances to the west. The team employed two different 3D scanning technologies: a mobile LiDAR mapping system (Hovermap) and a multi-view photogrammetry system known as the "Q" by Looq. These research efforts are integral to Loren's dissertation, and we hope **to support future ground-penetrating radar surveys and sediment coring** at select entrances with Loren and the team next summer.

"...investigating human and faunal access to caves during the Late Pleistocene and Early Holocene"

UCSD/UC RIVERSIDE: CHICHEN ITZA SCANNING

In early December 2024, we returned to Chichén Itzá to assist our partners from INAH, the University of California San Diego (UCSD) and UC Riverside, this time focusing on the area of **Chichén Viejo, also known as the Initial Series**.

One of the first areas of Chichén Itzá to have been properly excavated and studied in the late XIXth century, it contains the earliest known hieroglyphics of the entire site, which date to 619 AD. Built in the Puuc architectural style, the structures, which include several buildings and dozens of columns are believed to have served as villas for the elite of Chichén Itzá.

Over the course of a day, we assisted our colleagues by flying a Drone Deploy mapping mission 30 m above the site, flying a handheld drone mission to document the site and its ornate friezes on the facades of the buildings, and creating 360 panoramic images both above the site and at the surface.

Once again, it was a pleasure and a privilege to work at this UNESCO site. We wish to **thank José Osorio León and Francisco Pérez Ruiz of INAH, Dr. Travis Stanton of UC Riverside and Dr. Dominique Rissolo and Scott MacAvoy** for offering us the opportunity to collaborate again.

SISTEMA CRUSTACEA



One of the main exploration interests of 2023 for the team, Sistema Crustacea kept on challenging and revealing more this year too. **Water conditions, flow and visibility were quite demanding at times.**

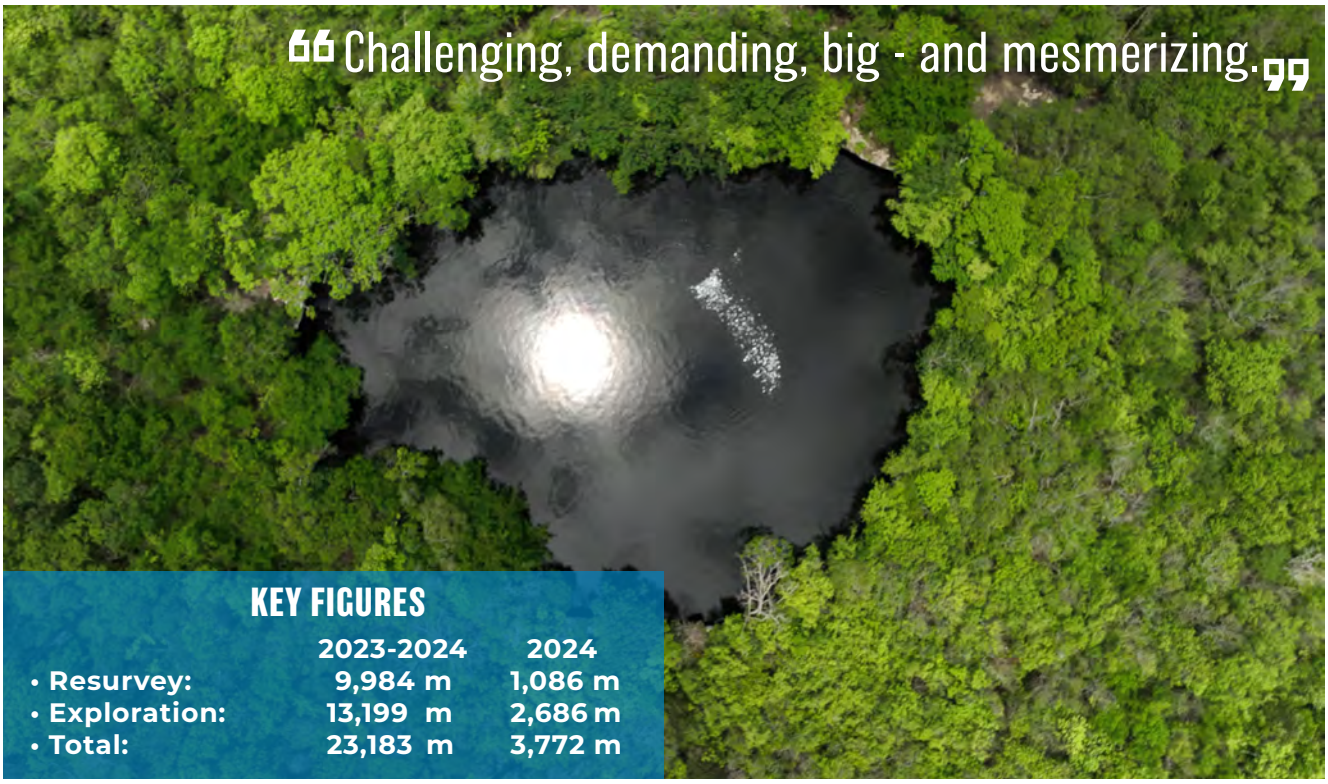
Except for a few dives from the beach going inland, most of the diving activities were started from across the highway in Cenote Rancho Tigre Grande property of Don Fernando Chico.

The cave stayed **as big as ever with major water flowing** in a classic northwest (upstream) to southeast (downstream) orientation, and heavy orange biomats coatings over most of the cave structure.

The team resurveyed 1,086 m of existing line. Some of the guidelines were in a very poor state, could not be trusted and were therefore replaced by new lines.

Most of the resurvey was conducted on some of the great early exploration work conducted by **Nicolas Casela and his team**, up to Cenote de Los Aluxes.

This year the total of **exploration** in Sistema Crustacea is just **2,686 m**, bringing the **total confirmed length** of the system to **23,183 m**. We are hoping for the water condition to improve soon, so we can get back to work in this mesmerizing cave system.



KEY FIGURES

	2023-2024	2024
• Resurvey:	9,984 m	1,086 m
• Exploration:	13,199 m	2,686 m
• Total:	23,183 m	3,772 m

FATHOM GEMINI CCR

2024 was the year where we committed to dive a **sidemount closed circuit rebreather (SM CCR)**. After a few years of SM CCR tryouts, we settled for the Fathom Gemini mCCR, essentially leaving our trusted side mounted Halcyon RB80/ RBK to play a second role in all future adventures.

Since April this year, we have tested the Gemini on most of our project dives. We were **able to gain experience in a variety of environments** from Ox Bel Ha, Ko'ox Baal, Crustacea, Tuun Ja, Punta Pajaros, Sac Actun, Vaca Ha, and The Dominican Republic. We feel confident we are able now to use the Gemini in different diving conditions, while completing a number of complex tasks.

We have been able to keep the same work ethic, productivity and efficiency as before, which was an important consideration for us in choosing the appropriate equipment.

Moreover, the added benefit of a smaller overall diving package, **gas efficiency**, and easier logistics especially for the upcoming base camp season in the caves of the Sian Ka'an Biosphere Reserve is very attractive to us.

As we are finishing up the year of project diving, we have collectively experienced nearly 850 hours on this rebreather unit with very satisfying results.

EXPLORERS CLUB - SEA STORIES 2024

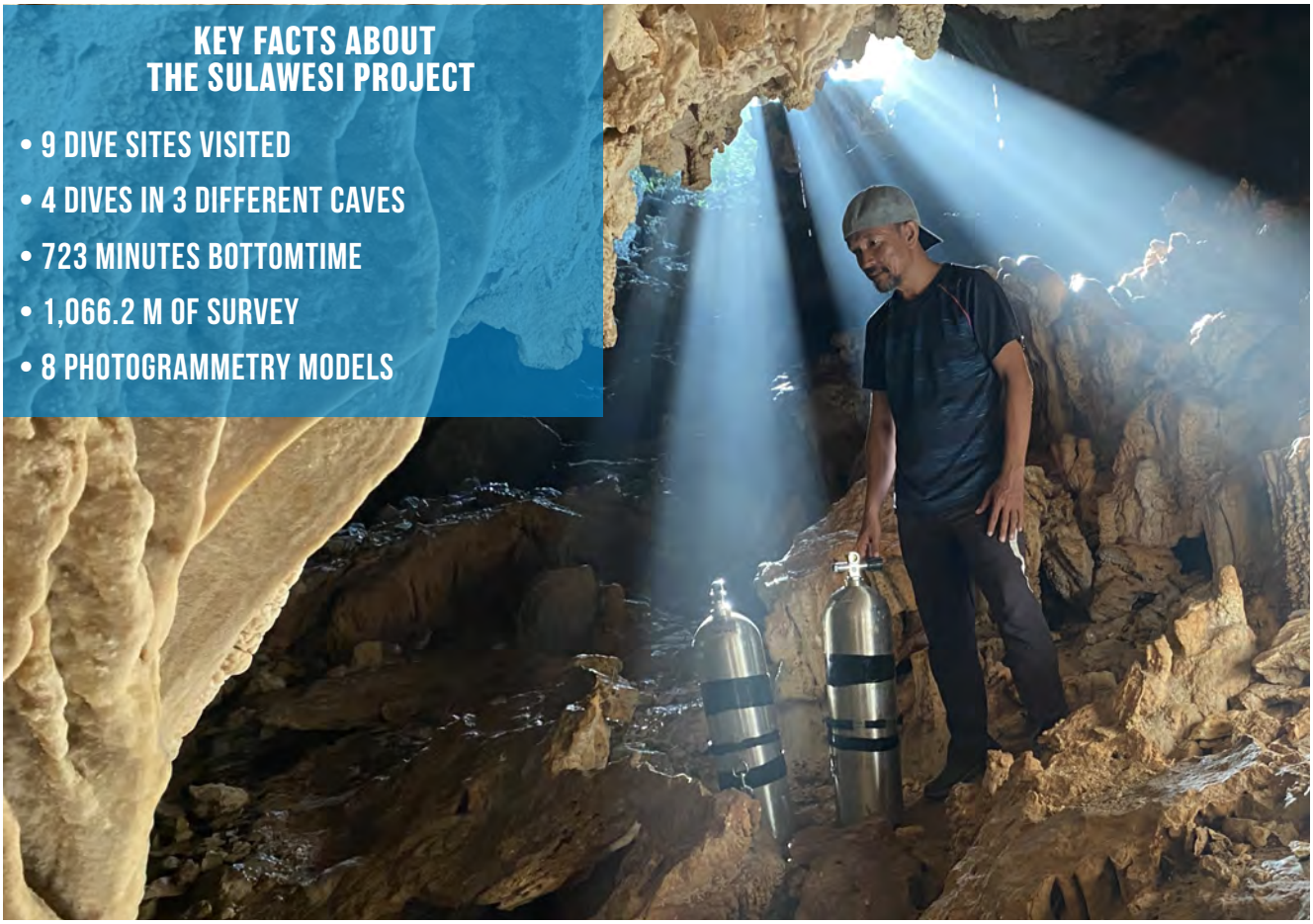
In November, Sam and Julien participated in the Sea Stories 2024 event hosted by **The Explorers Club of New York**. Their presentation, "Exploring the Aquifer of Mexico's Yucatan Peninsula in the Digital Age" highlighted CINDAQ's 25 years of dedication to exploring and protecting the Yucatan Peninsula's fragile aquifer system, including Ox Bel Ha, the world's longest underwater cave system.

They shared **how exploration has evolved from traditional techniques to leveraging cutting-edge technologies** like photogrammetry, LiDAR, and Geographic Information Systems (GIS). These advancements allow our team to better map, document and run analysis on our region's caves. They also emphasized our commitment to conservation and public outreach, with collaborations involving global media outlets that help to bring attention to the aquifer's importance.
We are **deeply grateful to The Explorers**

Club for hosting this event and to **Sean Holland** for organizing it and our friend **Martin Broen** for suggesting we participate. The opportunity to share our work with an audience passionate about exploration and conservation was invaluable. This platform allowed us to inspire others to think about the global application of our methods for preserving delicate ecosystems.

cindaq.org/cindaq-ec

SULAWESI, INDONESIA



KEY FACTS ABOUT THE SULAWESI PROJECT

- 9 DIVE SITES VISITED
- 4 DIVES IN 3 DIFFERENT CAVES
- 723 MINUTES BOTTOMTIME
- 1,066.2 M OF SURVEY
- 8 PHOTOGRAMMETRY MODELS

From April 15th to April 19th, Chris and Sam were invited, as part of a larger group of GUE divers, to **visit underwater cave sites in Southern Sulawesi, Indonesia**. Our objectives were to visit and assess as many cave entrances and underwater caves as possible; to survey and document as many of the caves as we possibly could; to document the area and its sites with drones and surface cameras to get a better idea of the landscape; to get to know the people, infrastructure and logistics of the area should we be return in the future.

All arrangements for our group were coordinated by **Chee Hoon Ong** and the logistics from our arrival to departure were magnificently handled by **Halim Maswar, Sudiar Subu and the team at Rock and Roll Divers (RRD)**. Rock and Roll Divers are based out of the port city of Baubau located on the southwest corner of Buton Island. Without their support this project would have been extremely difficult, if not impossible to undertake. RRD has a base camp office in Baubau with compressors, a full complement of tanks, personnel and the vehicles required to move divers from location to location. More importantly, Halim and Sudiar have established themselves in the area and built up strong relationships with the communities who own the cave entrances. This meant that all we had to do was show up at the dive

site and go for a dive. We are extremely grateful for their support. We stayed at the Zenith Premiere Hotel in Baubau on the first and last nights. While on Muna Island we stayed at the Kadena Glamping Resort, a deluxe resort recently built to cater to visiting cave divers.

Our underwater objectives were to simply **apply our methods of cave survey and documentation in as many sites as we could**, despite the limited time that we had. This not only provides tangible data to the RRD, but also allows them to see first hand the way in which we work and operate.

During our four days in the area, we visited 9 potential dive sites on Muna Island. We did a total of 4 dives in 3 caves (Goa Kapondaponda, Goa Wandoke, Goa Sanktum) for a cumulative bottom time of 723 minutes. We were able to resurvey a total of 1,066.3 m of existing cave line and collect data for 8 underwater photogrammetric models. It is always interesting for us to travel to other parts of the world and dive into caves to see how they compare with what we have in Mexico. The caves of Sulawesi did not disappoint us. We were interested to see the similarities such as **the presence of ochre deposits within the caves and ceramics in many of the entrances of caves**. Equally interesting were the differences in cave biology, and cave morphology.

There is little doubt that this area holds a lot of potential for further cave exploration and research. What struck us most was **the kindness of the people, the natural beauty and the vibrant culture** that flourishes there. A virtual tour of the Muna Island Region can be found at:

cindaq.org/muna-360

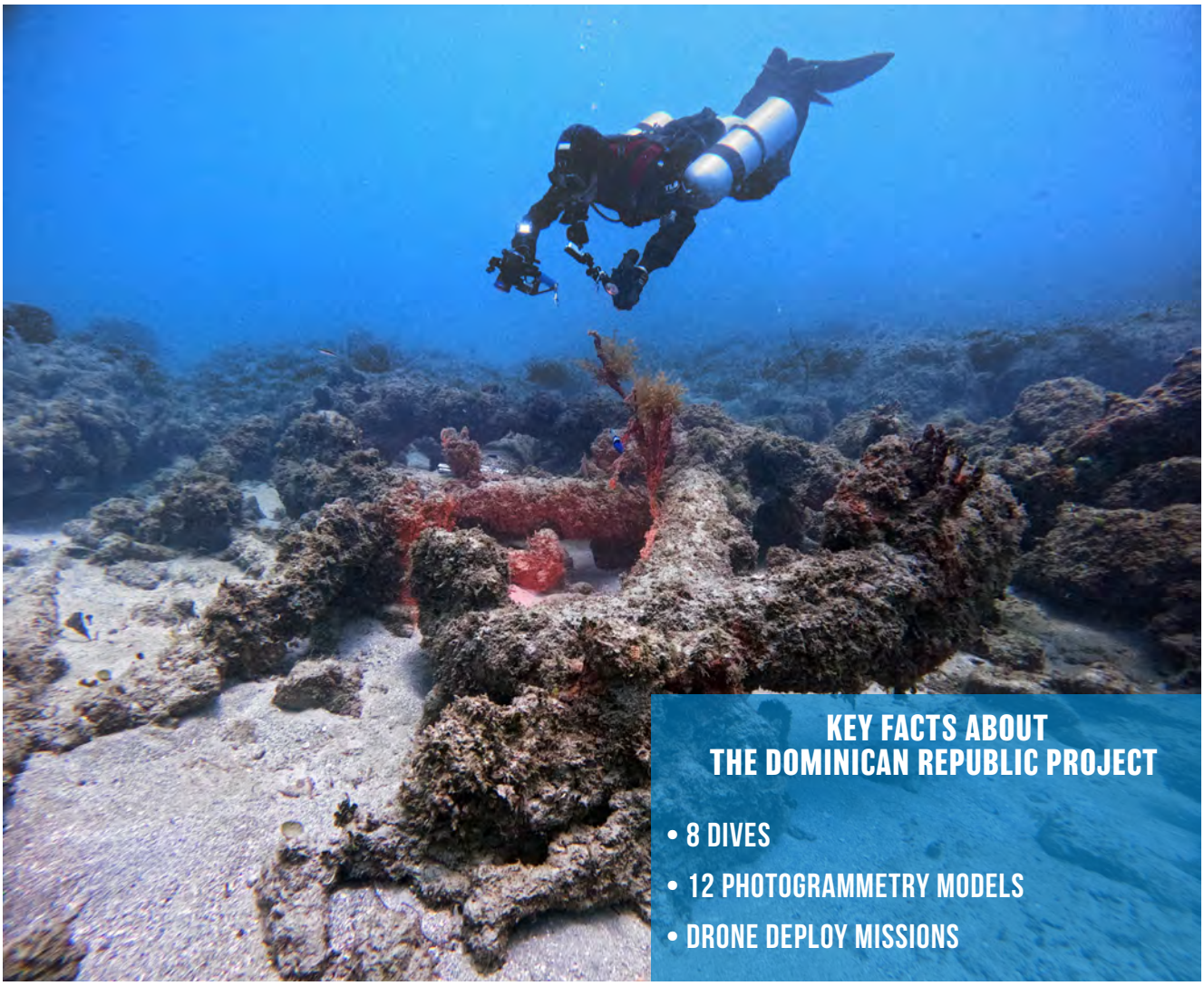
DOMINICAN REPUBLIC

From May 23th to May 28th, 2024, we participated in a project to **assess and document the maritime landscape of the La Isabela National Park, located in La Isabela, Dominican Republic**. This project was conducted under the supervision of **Dr. Juan Mubarak** and **Dr. Pedro Morales** of the Ministry of Culture of the Dominican Republic, **Ulrike Guerin** of UNESCO, and **Msc. Helena Barba Meinecke** and **Dr. Dolores Elkins** of the UNESCO Science Technology Advisory Body (STAB) for the 2001 Convention on the Protection of the Underwater Cultural Heritage.

In line with the UNESCO 2001 Convention, this mission's objective was to provide crucial insights into the history of Columbus' arrival and the local Taíno culture at the time of contact. The project was funded by the Spanish International Cooperation Agency for Development.

The STAB provides advice and assistance to the Meeting of States Parties on technical and scientific issues relating to underwater heritage. CINDAQ received the invitation to participate as an accredited NGO with the 2001 Convention. An additional 15 underwater heritage experts collaborated with UNESCO to ensure the highest level of scientific standards.

The mission identified, assessed, and documented underwater heritage within and around the Bay of La Isabela, in the hopes of detecting six to eight wrecks from **Christopher Columbus' fleet**.



KEY FACTS ABOUT THE DOMINICAN REPUBLIC PROJECT

- 8 DIVES
- 12 PHOTOGRAMMETRY MODELS
- DRONE DEPLOY MISSIONS



The research project also included the documentation of the ruins of La Isabela's port structures, the harbor of Columbus' first settlement in the Americas, and the foundations of Columbus' house, which is now threatened by coastal erosion and risks collapsing into the sea. Given the site's historical and touristic significance, urgent measures are needed to preserve it for future research.

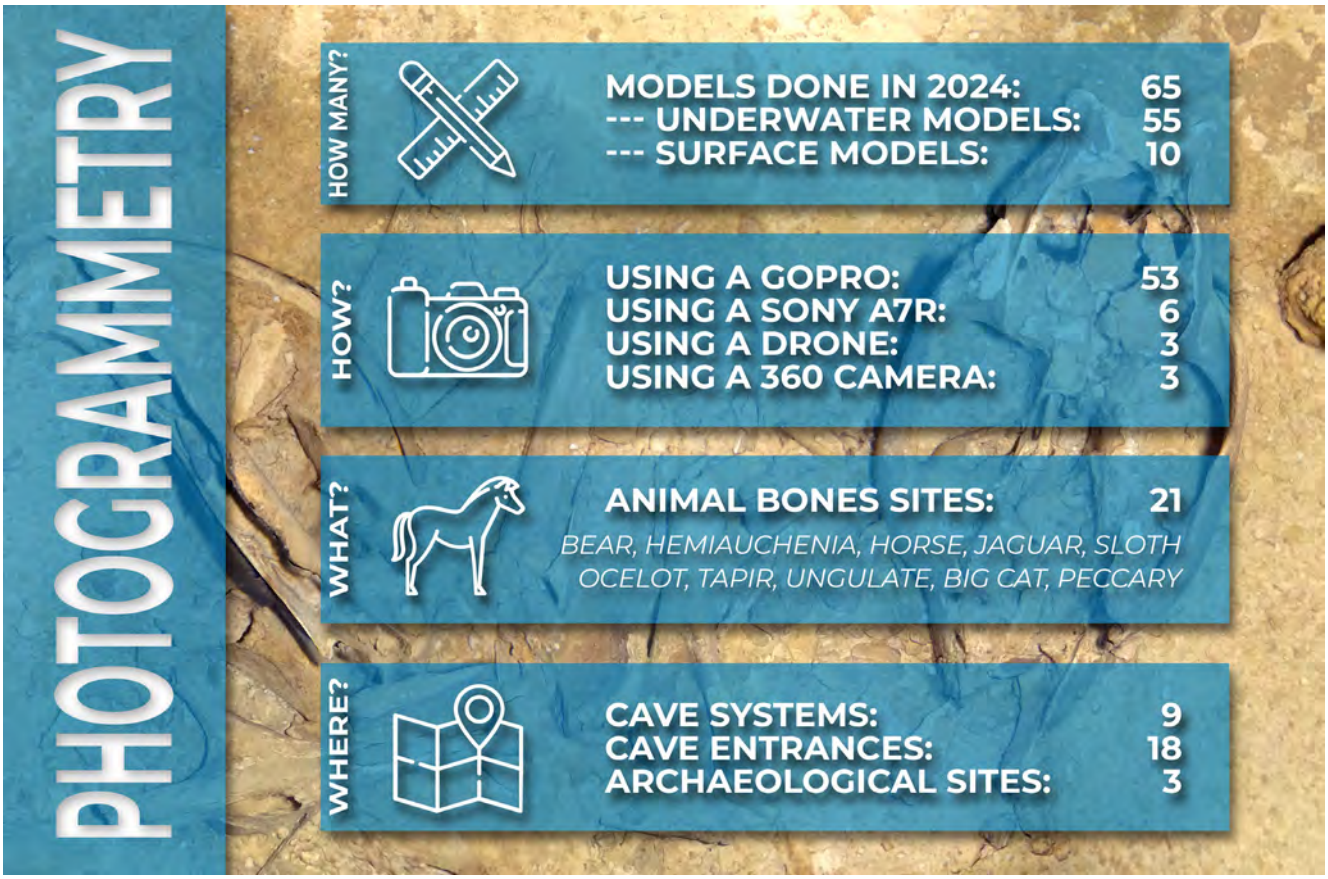
As part of the mission, UNESCO also advised local communities on how to sustainably manage and conserve their region's sunken heritage. This involved training two young underwater archaeologists from the Dominican Republic to assess such sites and conduct future research. UNESCO's team also provided support to the site's museum and helped prepare for urgently needed artifact conservation.

CINDAQ assisted with photogrammetry and overall documentation of the project both above and below the surface. We completed a total of eight dives in very shallow coastal areas, creating 12 photogrammetry models of in situ artifacts from various wreck sites. Although none of Columbus' ships were located, several other wrecks were identified, each offering insights into the maritime landscape. On land, we assisted Dr. Isabel Rivera-Collazo and doctoral candidate Diana Pena Bastalla of the Scripps Center for Marine Archaeology by documenting the site of La Isabela and surrounding Taíno settlements with drones and mirrorless cameras. Deliverables included **Drone Deploy mapping missions, photogrammetric models, and 360° images** compiled into a virtual tour of the area (*cindaq.org/la-isabela-360*). These models will aid in determining the extent of coastal erosion and how to mitigate its effects in the future. Additionally, Fred filmed and edited a short film about the project (*cindaq.org/la-isabela*) and conducted interviews with local fishermen whose expertise guided us to the sites we documented.

We thoroughly enjoyed our time and appreciated the opportunity to collaborate with world experts. We are **especially grateful to Helena Barba Meinecke, Dolores Elkins, and Ulrike Guerin** for including us in this project, and **to the community of La Isabela, Juan Mubarak, Pedro Morales, and Francisco Gomez** for their warm welcome. We look forward to further assisting UNESCO and the STAB on future projects and returning to the Dominican Republic.

PHOTOGRAMMETRY: 2024 SUMMARY

In 2024, we continued **to document paleontological, archaeological and geological sites both above and below the water** using photogrammetry. This non invasive technique allows our partner scientists to study the incredible features of underwater caves from the comfort of their homes or offices at the surface, while also **preserving the caves and their content**.



PHOTOGRAMMETRY AUTOMATION

In 2011, we published an article in **The International Archives of the Photogrammetry, Remote Sensing, and Spatial Information Sciences of the International Society for Photogrammetry and Remote Sensing**: "*Environmental Challenges, Technical Solutions, and Standard Operating Procedures for Data Collection in Photogrammetric Studies Toward a Unified Database of Objects and Features in Underwater Caves in Mexico*."

The main idea was **to define a new image acquisition methodology built around a GoPro camera**, creating a compact and replicable setup that could document objects previously inaccessible with traditional methods. An equally important goal was to scale up the production of photogrammetry models to gather more data points throughout the caves. This initial phase focused on fieldwork and the data-collection aspects of photogrammetric studies.

We then turned our attention to **standardizing the model generation process**. In 2022, as part of our internal

documentation platform, Wikindaq, we documented most of the settings and procedures our team should follow for each step of photogrammetry model creation. This included everything from organizing image files to publishing models, covering picture alignment, point cloud creation, filtering, scaling, and more.

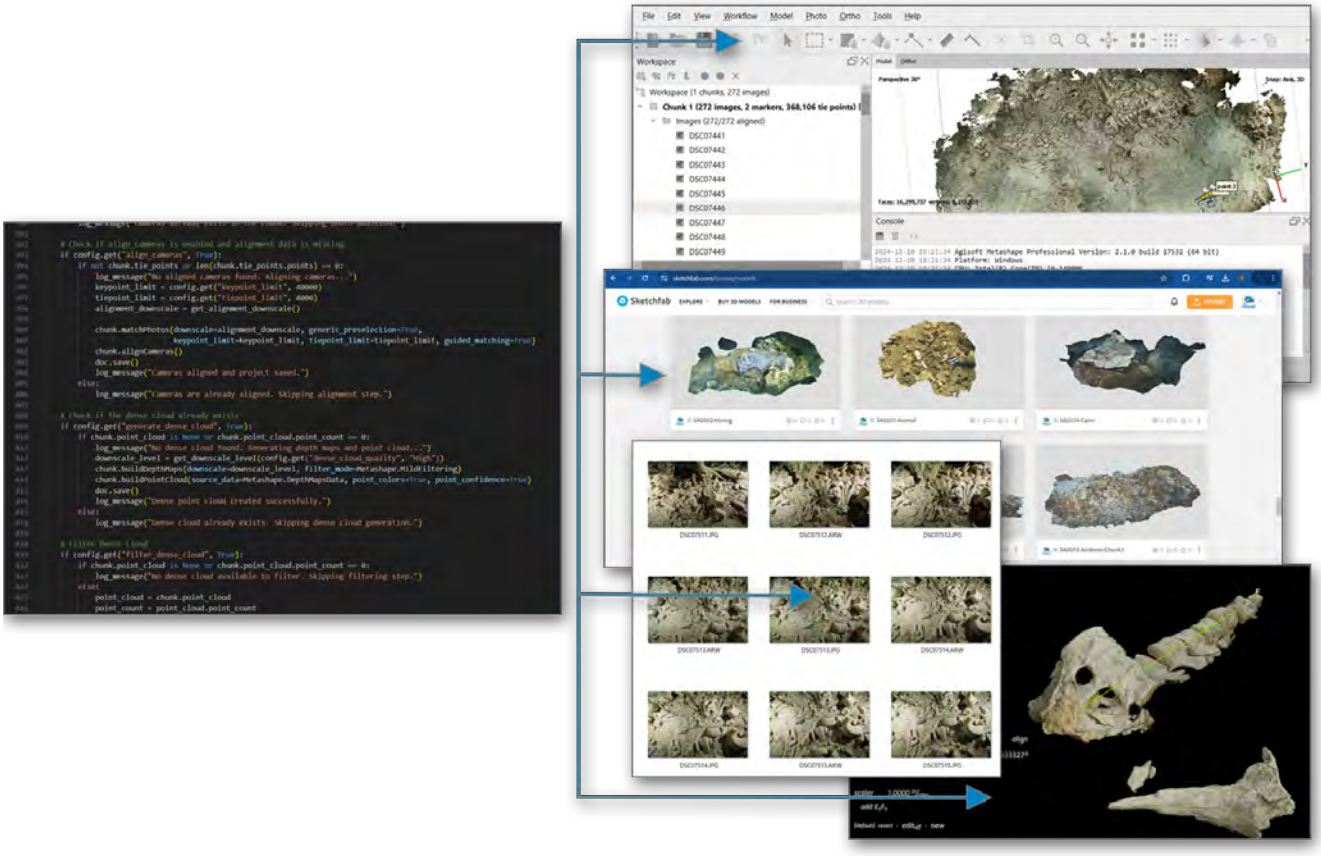
In 2023, we took this documentation further by **interconnecting these separate articles into a comprehensive and organized workflow**. This workflow chronologically listed all the steps required, from preparation to publication of a 3D model. This approach provided us with a complete tool to ensure:

- Consistency in the methods used by team members to create models.
- Uniform storage and analysis techniques for all models.
- Streamlined training for new collaborators.

The next logical step was **to automate the photogrammetry process, making it as seamless and efficient as possible to further scale up production and save time**. Since each step had been thoroughly documented and settings saved, we were able to break the process into manageable components. These components were fed into an artificial intelligence, which generated two dozen Python scripts leveraging the APIs of the various software tools in our workflow. Our team then reviewed, refined, and embedded these scripts into a unified program.

This program automatically transforms model images, stored in a structured folder, into all the necessary outputs: aligned images, a point cloud, noise filtering, a mesh model, an orthomosaic, and exports for our scientific partners. Now installed on a powerful workstation and accessible via a simple drop-down menu, this tool leverages the experience and documentation work of the past three years. **It reduces the time and effort required to build a model by a factor of at least five.**

We are thrilled to use this new tool to document even more of the incredible paleontological, archaeological, and geological features of our beloved caves.



PHOTOGRAMMETRY & GIS INTEGRATION

With the new process to import survey data into our Geographical Information System (GIS), we were able to extract relevant information from the survey comments, like for instance Photogrammetry Unique identifiers. Since these were also used for earmarking all data related to the photogrammetry models across our different storage and processing platforms, we decided to develop an array of tools to **automatically link our GIS to our Network Access Storage (NAS), our DropBox account, Sketchfab, and the central database listing all our models**.

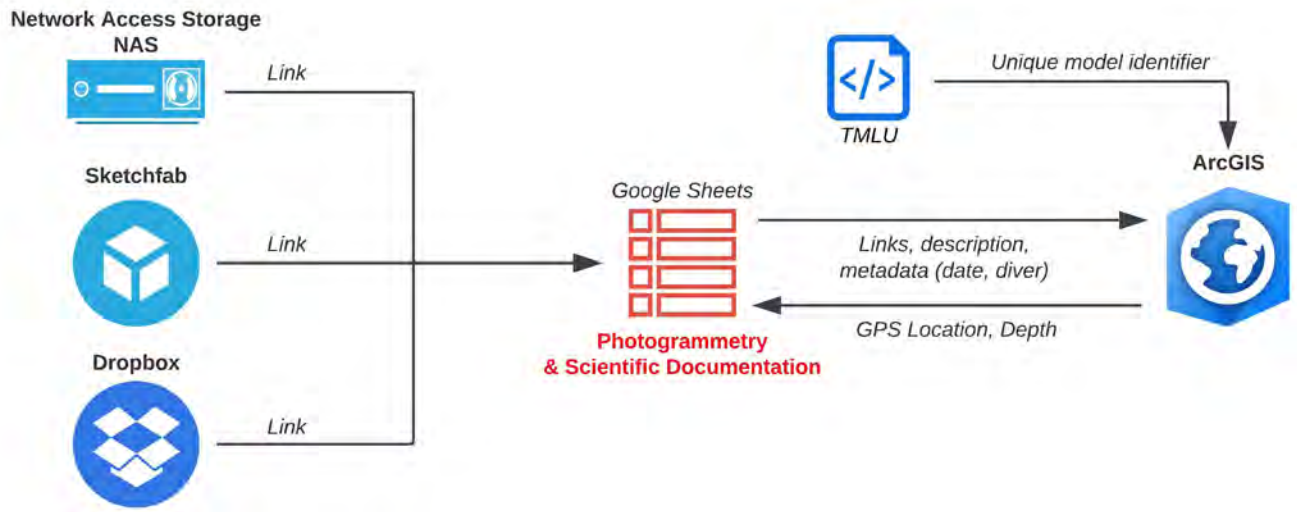
We have tested different ways of keeping an up-to-date list of models over the years, from an ESRI Survey 123 feature layer to a simple folder containing all models, over private webpages. The system that ended up being used the most by our team was a simple Google Sheets summarizing the information of each model, along with its location, depth, expert assessments and other useful metadata.

Keeping a Single Source of Truth (SSOT) architecture for storing the list of photogrammetry models seemed to make a lot of sense in terms of **data consistency and ease of use**, and we therefore decided to start from this Google Sheet and make it our SSOT, from which the GIS system could then pull information to present to our team members and partners.

Out of over 200 models, only twenty percent presented with complete information. The first phase of work, which lasted about a month, was to clean up the list and recover missing information from various sources including our NAS, our mailboxes, Whatsapp conversations, and Zoom calls recordings. This led to the development of a first series of tools to identify problematic records, assess our progress, and recover links to the model-related data.

Once the Google Sheet was cleaned up, we were able to develop a second series of tools to establish a two-way communication between the Google Sheet and our GIS: model information (date, divers involved, expert assessment) are pushed from the Google Sheet into our GIS, while the exact GPS coordinates of each model are pulled from the GIS into the Sheet. This exchange has then been implemented into our Ariane-to-GIS import tool.

The result is:
- A cleaner list of available photogrammetry models for our team and our scientific partners, as a Single Source of Truth (SSOT)
- The possibility to **see the location of all models on our web map** and to directly click on automatically generated links to see the models and the associated data.
- A modular structure where the SSOT could be replaced by any database format, from a GIS Feature Layer to a SQL table.



GOPRO : QR CODE FOR PHOTOGRAMMETRY

Using GoPro cameras underwater presents **unique challenges because their housing limits access to only two buttons**. Adjusting settings mid-dive becomes impractical, making it difficult to configure tasks like photogrammetry or video documentation.

Traditionally, we set everything before the dive using the touchscreen, but this method omitted features like minimum shutter speed, histograms, or higher video bitrates.

The introduction of GoPro Labs, an experimental firmware available on models like the HERO12, has solved many of these issues. By generating a QR code with detailed settings and scanning it, **we can instantly apply complex configurations without menu navigation**. This streamlines pre-dive preparation and adds advanced features like histograms and level indicators, which are absent in the standard firmware.

We use GoPros for photogrammetry multiple times a month, especially when documenting new cave discoveries. Photogrammetry requires abundant, clear images from many angles with minimal shadowing. We use photo timelapse mode configured via QR code, letting the camera capture images at one-second intervals automatically. A key feature is the histogram display, which helps us adjust exposure on the fly. We prefer a large histogram for precise adjustments when shooting photos in low-light cave environments and a smaller one for regular video to reduce screen clutter while retaining vital exposure information.

Despite these advantages, scanning different QR codes for each setting change can be cumbersome underwater. For dives requiring both photogrammetry and video, we then rely on two separate codes, one for each mode. Lining up the camera to scan the right code can be difficult in low visibility or cramped cave conditions.

We asked David Newman, the GoPro Labs developer, if permanent detailed settings could be stored per preset in the camera, allowing us to switch between modes without repeatedly rescanning. David confirmed that this feature, already on the HERO13, is coming to the HERO12 in a future update.

Once available, it will **streamline our workflow significantly** by letting us embed and recall custom settings (e.g., histogram size, ISO limits, and shutter speed) within different presets. We can then switch from photogrammetry to video modes seamlessly, retaining all critical configurations. For CINDAQ's data collection efforts, this flexibility ensures consistent, high-quality documentation of cave environments, enhancing research accuracy and conservation planning.

Overall, discovering GoPro Labs' QR code functionality has **improved how we capture cave imagery. By leveraging these upcoming improvements, we can collect richer datasets in even the most challenging conditions, pushing the frontiers of underwater exploration.**

SURVEY COMMENT VALIDATION TOOL

Over time, managing cave survey data presents some challenges, especially when converting information collected while diving from a human-readable format into one that computers can efficiently process. This often leads to several issues:

• **Human Error in Data Entry:** Surveyors may unintentionally deviate from the standard data format, resulting in inconsistencies and errors.

• **Inefficient Data Processing:** Non-standardized data hampers our ability to automate processing and analysis, slowing down workflows.

• **Delayed Error Detection:** Without immediate feedback mechanisms, mistakes can go unnoticed until much later, making corrections more difficult.
To tackle these challenges, we developed a Survey Comment Validation Tool.

This tool automates the validation process of our survey data by performing the following key steps:

• **Automated Syntax Checking:** Every time a TMLU file, a data file generated by Ariane, our cave survey software, is pushed to GitHub, the tool automatically scans the comment sections. For those unfamiliar, GitHub is an online platform that allows us to store and manage our files collaboratively. The tool checks for specific patterns in the data, such as markers, navigation, leads, biological observations, and flow directions.

• **Color and Section Name Verification:** The tool cross-references color codes with corresponding section names based on a predefined mapping. For example, sections starting with “RES” should have a specific color code. This ensures consistency and accuracy in our data representation.

• **Immediate Error Reporting:** When discrepancies are found, the tool generates a detailed report indicating the station ID, the problematic comment or section, and the nature of the issue. This report is sent directly to the person who submitted the file, enabling swift corrections.

This is what AI thinks we do...

For instance, a surveyor might record a line that needs resurvey as “DM article CINDAQ24 ; Jump N ; #Resurvey ; #Lead S; #Biology shrimp 2024-11-24” instead of the standardized “DM Article CINDAQ24 ; Jump N #Resurvey ; #Lead S; #Biology shrimp 2024-11-24”. The extra “;” means the data won’t be recognized correctly during processing. The tool detects this subtle error and notifies the surveyor to amend it.

• Implementing the Survey Comment Validation Tool has yielded several benefits:

• Improved Data Quality: Early detection and correction of errors prevent the propagation of inaccurate data, ensuring the reliability of our databases.

• Enhanced Efficiency: Automation reduces the time surveyors spend on manual data checks, allowing them to focus more on exploration and data collection.

• Standardization of Data: Enforcing data entry standards promotes consistency across datasets, which is crucial for effective analysis and integration with other systems.

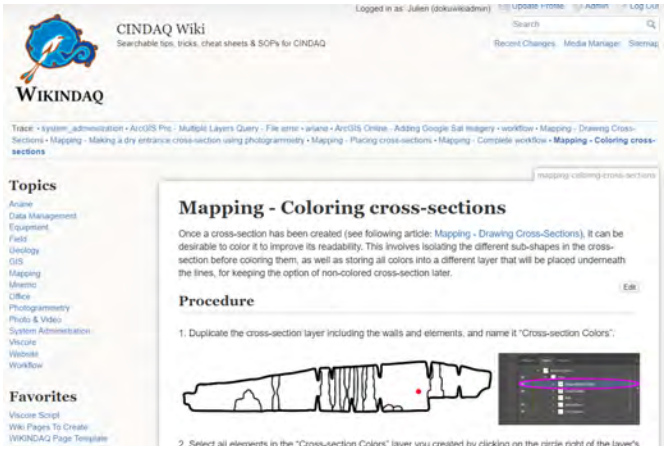
This tool has **significantly streamlined our data validation process, bridging the gap between human data entry and machine-readable formats**. It not only enhances the quality of our data but also improves operational efficiency.

Moving forward, we plan to expand the tool’s capabilities to cover additional validation scenarios and integrate it more closely with the surveyors’ data entry systems. This will further support better decision-making based on accurate and reliable information.

WIKINDAQ

WIKINDAQ, CINDAQ’s internal Wiki, organizes and stores critical SOPs, workflows, and instructions. By the end of 2022, it had 100 articles covering various operational areas. In 2023, another 100 articles were added, emphasizing interconnected workflows, including a comprehensive photogrammetry workflow, user management, and backup systems. These updates improved consistency, standardization, and data security.

In 2024, WIKINDAQ saw significant advancements:



WIKINDAQ : KEY FIGURES

- 300+ ARTICLES
- 15 CATEGORIES

1. Cave Mapping Workflow: A new workflow was introduced for cave mapping, covering field methods, digital map integration, dry cave entrance photogrammetry, and cross-sectional mapping. This addition ensures consistent methodologies and enhances project efficiency.

2. System Administration Documentation: Detailed system administration procedures were developed to support WIKINDAQ’s growing IT infrastructure. These documents provide administrators with robust tools to monitor and troubleshoot the platform.

3. Ariane-to-GIS Tool Redesign: The new Ariane-to-GIS tool, streamlining the conversion of TMLU files and improveing the workflow by significantly reducing processing time, was documented in details to make future developments easier.

IMPORTING SURVEY DATA INTO GIS

While Ariane is the software of choice at CINDAQ for entering cave survey data due to its ease of use and seamless connectivity with the Mnemo device, it lacks many functionalities for data sharing and analysis. To address these needs, CINDAQ uses ArcGIS to display, share, analyze, process, and query cave survey data. ArcGIS Pro provides powerful geoprocessing tools, while ArcGIS Online offers an intuitive platform for displaying and sharing data with team members and scientific partners.

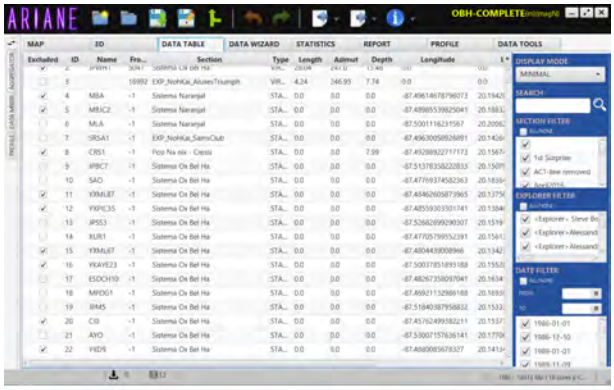
Since Ariane stores survey data in a proprietary format called TMLU, which is not recognized by ArcGIS, a tool was needed to import Ariane data into ArcGIS. Wetherbee Dorshow of Earth Analytics developed the first version of such an import tool in 2020, which has since undergone several improvements.

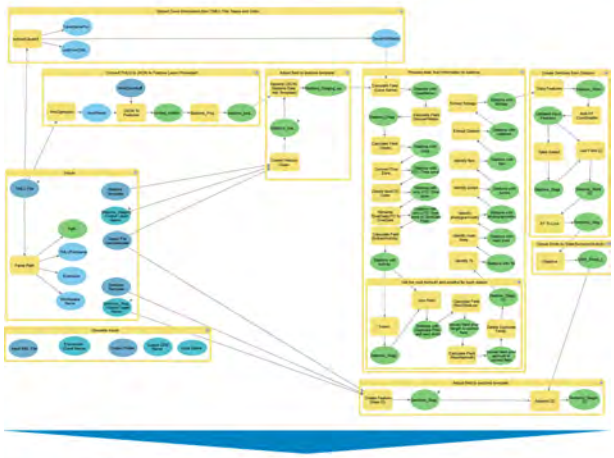
However, as CINDAQ's data has grown in both quantity and complexity—with cave systems spanning several hundred kilometers in a single file and survey comments increasingly containing detailed information about navigation, flow, geology, biology, photogrammetry models, and more — the Ariane-to-GIS tool began reaching its limits. **A new tool became necessary** to handle the following issues:

1. Cumbersome Export Process: The need to draw the TMLU file with loop closures in Ariane before export, fix formatting issues in Google Earth Pro, and use KMZ as an intermediary format. This process could take 15–30 minutes for large files and often caused program crashes.

2. Overloaded Comments: Survey comments in Ariane, and subsequently in ArcGIS, were becoming larger and harder to read due to the volume of embedded information, reducing their usefulness for scientific purposes.

3. Limited Query Options: Dates and explorer/surveyor fields were only





searchable for stations (points) in ArcGIS, not for shots (polylines), making it nearly impossible to perform meaningful line-based queries.

4. Increasing Complexity: The import tool's layered updates over time had made it increasingly difficult to edit or improve.

To address these challenges, a new tool was developed in the first three months

of 2024. At CINDAQ's request, our good friend Håvard Sørbø designed a Rust program that directly converts TMLU files into GeoJSON format. This critical piece of code eliminates the need to redraw TMLU files in Ariane with loop closures, export them to KML/KMZ, and fix file formatting with Google Earth.

Building around this GeoJSON conversion kernel, we developed a new ArcGIS Pro model from scratch, structured into well-defined building blocks and thoroughly documented for future development. Key improvements include:

• **Streamlined Data Extraction:** Extracting relevant information from Ariane's comments, such as photogrammetry unique identifiers, flow data, and navigation points (Ts and jumps), and storing this information in separate fields to enable complex queries and analyses.

• **Enhanced Data Structuring:** Importing and structuring stations first, then generating shots from the stations to retain maximum information for line-based queries.

• **Simplified Workflow:** Reducing the number of parameters the user must input, making the process more straightforward.

The new workflow has proven **significantly faster, reducing processing time for large cave systems from 30 minutes to under three minutes**. More importantly, it provides a robust tool that enables more in-depth scientific work and serves as an adaptable platform for integrating additional analysis tools in the future.

This is just the beginning!

SCIENTISTS' ANALYSIS : AUTO TRANSCRIPT ↓

CINDAQ collects **video-recorded conversations from scientific partners, capturing valuable insights for subsequent analysis**. By extracting audio from these videos and transcribing it with the OpenAI Whisper model, we ensure highly accurate transcripts that are easily searchable and shareable.

We have found the Whisper model to be significantly more precise than built-in transcription services in Zoom or Adobe Premiere, which is why we developed a custom Python script for the job.

With these precise transcripts, our team can quickly review key moments, reference specific segments, and seamlessly pass this content to other large language models like the GPT O1 model for **generating meeting minutes or summaries**. This approach helps surface vital information more effectively and supports deeper data exploration with our team and partners.

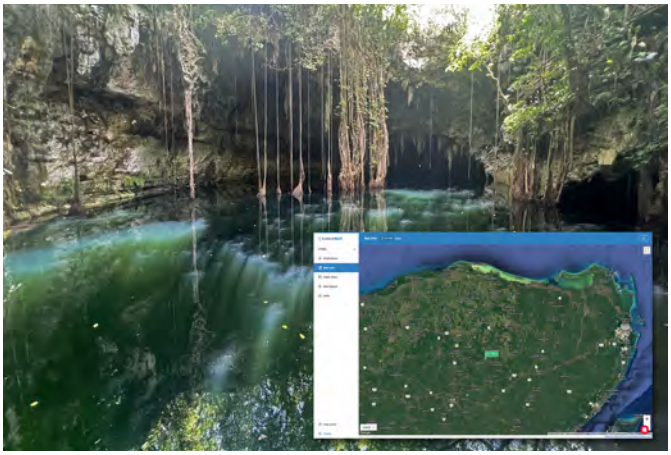
Incoporating this into our workflow, along with the new GIS import tool, the automatic link generation and the photogrammetry automation script, we can now discover and document a new site of interest, generate the corresponding photogrammetry model and **share it with scientists on the same day**. The subsequent video-call with expert analyzing the finding is then transcribed and turned into a usable report in a matter of hours.

CENTRALIZED PROCESSING WORKSTATION

We recently acquired a new rack-mounted workstation from Puget Systems, equipped with an Intel Core i9 processor, 192GB of RAM, and an NVIDIA GeForce RTX 4090 GPU. This powerhouse **dramatically accelerates our workflows**, especially the new, automated photogrammetry workflow, enabling rapid processing of large image datasets. The generous amount of RAM allows us to handle multiple projects simultaneously without slowing down, while the high-end GPU significantly reduces rendering times.

Another major advantage of this workstation is how easily our entire team can access it. All of our equipment is secured behind a firewall, ensuring a private, secure connection for everyone. Paired with our Starlink satellite internet, team members, whether at the main office or in the field, can log in and collaborate on resource-intensive projects in real time. While operating remotely, rugged **Dell laptops** gather and upload data directly to the centralized workstation, streamlining file management and eliminating the need for multiple isolated less powerful hardware setups.

REMOTE AQUIFER MONITORING: RANCHBOT



We continued exploring options for remotely monitoring the aquifer, building on past work with Dr. Richard Wylde and the Internet of Things (IoT). **Long-time CINDAQ supporters Will and Pam Harte**, inspired by our 2023 annual report, suggested Ranchbot remote tank monitors as a potential solution. **Ranchbot** provides monitoring systems designed for ranchers, offering real-time insights into water levels. These solar-powered, autonomous units support up to five wired and ten wireless sensors, connect via satellite 24/7, and are easy to install and maintain.

Will and Pam connected us with Andrew Coppin at Ranchbot, and a unit was quickly shipped to Mexico. We reached out to Sara Fuentes and Alfredo Medina, owners of Cenote Chenxunan, who agreed to host the monitor as a proof of concept. In August, we installed the unit with a depth sensor beneath the cenote dock. To date, we believe this is **a reliable solution for collecting and transmitting data from remote locations**. We are collaborating with Ranchbot and other manufacturers to integrate sensors for pH, dissolved oxygen, temperature, precipitation, and conductivity. We are motivated by the potential for a cost-effective aquifer monitoring system. Once a prototype is ready, we plan to seek funding for 25–50 units to deploy across the peninsula. **We are deeply grateful to the Hartes and Ranchbot for their support.**

DELL COMPUTERS - TESTED IN THE FIELD

Over the course of the last year, we received **three ruggedized computers from Dell**. After meeting **David Plourde of Dell** at the ESRI Users Conference in 2023, he became interested in our work and was convinced that, given the remote and often challenging areas we work in, the Dell rugged computer line would be of great use to us. Since receiving the laptops, we have put them to the test, using them in a variety of situations where, previously, taking a computer into the field would not have made sense.

For our camera trap data collection, we can download, review, and reformat the SD cards in the field without needing to remove the cameras. Using ESRI Field Maps on the tablet, we can log points, lines, and polygons in the field on its high-contrast screen, as we did in the blazing sun at Punta Pájaros in September.

The laptops were also used for **calibrating field instruments**, such as our YSI sonde at Cenote Tuun Ja and the Ranchbot Monitor at Cenote Chenxunan.

In the Zona Núcleo of Sian Ka'an, we successfully flew a Drone Deploy mapping mission and then **uploaded the resulting images using the Dell laptop via Starlink for processing**. We were able to view the results while still in the field—something that would not have been possible before. By powering the computers with our EcoFlow batteries, we streamlined the process of cave mapping by entering survey data in the field, **printing the results on waterproof paper, and immediately beginning to sketch**. Previously, this would have been a two-day process.

In the Dominican Republic, we were able to process and visualize photogrammetric models. As we begin using our Puget Systems workstation, we see the Dell computers becoming a valuable interface, connecting us from the field to our powerful computing station in the office.

We are grateful to David and Dell for providing us with these invaluable tools.

CAPTURING THE PULSE OF THE AQUIFER

Following up on work from the past few years, we continue to make progress towards our goal to monitor the aquifer of the entire Yucatan Peninsula in real time.

Dr. Richard Wylde's persistence and expertise lead the way with two experimental approaches.

The first was **antenna-based utilizing LoRaWAN to transmit data over a long distance** but requiring the path between transmitting and receiving antennas not to be obscured by vegetationt. An expected increase in shared antennas in the future might make this more feasible but for now this method is really not viable to cover the entire peninsula.

The other means of data transmission has been by **sending a signal upwards to a satellite** which then sends the data to CINDAQ headquarters via the internet. It's quite clear that this is currently the best way forward but the first unit purchased and installed has since been discontinued after the company was purchased and buried by Space X.

SHARED KNOWLEDGE

Apart from the benefits of CINDAQ knowing more and sharing insights into the aquifer we feel that helping develop the technology could be invaluable to others in order to monitor, study, better understand, appreciate and conserve our aquifer.

GEOLOCATION UNDERWATER

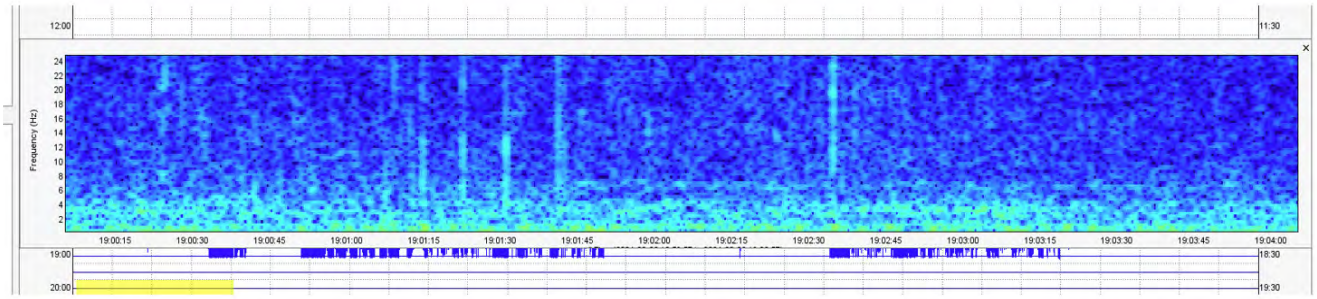
Accurately knowing the position of an underlying cave becomes increasingly interesting as we look **to expand exploration from single entry caves** and in consideration of expanded development in our area above cave passages.

Years ago, Dr. Richard Wylde developed and **experimented with a magnetometer to improve the accuracy of mapping shallow underwater caves**. With improved sensitivity of today's magnetometers the experiment is being repeated. The initial tests of a smaller magnet were successful with a clear signal detected on the surface through some 10 m of rock. An additional magnetometer will be needed on the surface for triangulating the position and establishing a much more accurate geo-location of the underlying cave.

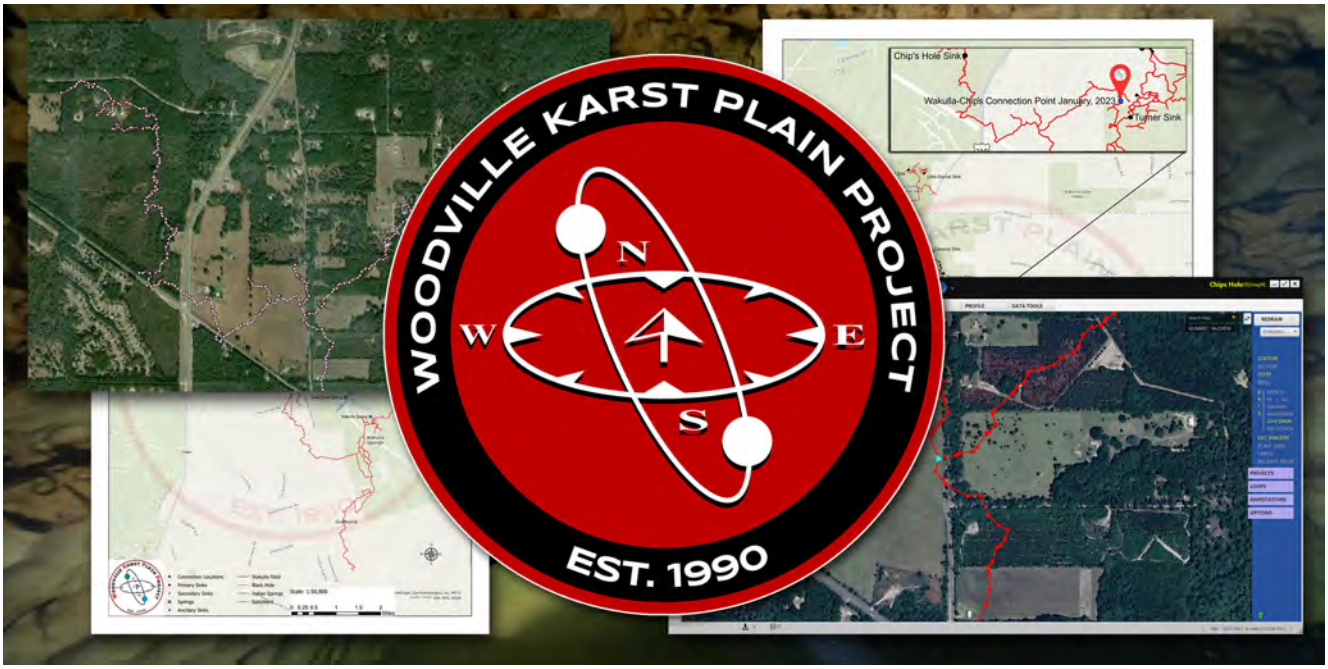
Always on the lookout for interesting cave related studies, Dr. Wylde brought a Raspberry pie powered vertical motion seismograph (Raspberry Shake 1D) and we placed it on solid ground above the cave. From 10 m below we struck the cave ceiling and were able to detect the slight vibration.

In order to detect a signal not directly below, a unit measuring vertical and horizontal movements (Raspberry Shake 3D) will be experimented with in the new year and could also lead to **pinpointing the geo-location of underwater caves**.

Apart from improving the accuracy of underwater caves it is possible for seismographs to **help detect and document human development impacting caves**.



COLLABORATION WITH THE WKPP, FLORIDA, USA



The Woodville Karst Plain Project (WKPP) is a project and organization that has been mapping the underwater cave systems of Northern Florida since the 1980s. For cave divers, it is a legendary exploration group that **has pioneered many of the protocols and ideas still widely used today**. The WKPP also served as the inspiration for the creation of Global Underwater Explorers by Jarrod Jablonski.

The CINDAQ team and WKPP members have been friends for a long time, both in the water and on the surface. Starting in 2022, we began collaborating **to replicate some of the GIS functionalities used by CINDAQ for the WKPP**.

In 2022, our friend Wetherbee Dorshow (Earth Analytics) established the main framework for the WKPP by providing an ArcGIS Pro license and a hosted solution for their survey data in ArcGIS Online. He also created a WKPP-specific version of his SmartCave Manager interface.

In 2023, we shared some of our ideas on the advantages of using standardized comments when entering data into Ariane. Based on this, Chris Werner and John Rose undertook significant cleaning work on their survey data as part of a much broader project focused on the historical archives of decades of WKPP work.

In 2024, we assisted the WKPP in implementing our new conversion tool for importing TMLU data from Ariane into ArcGIS. As is often the case with collaborations like this, **the process proved to be mutually beneficial**: not only was it enjoyable to work together, but extending our tools to other projects helped us discover unique local specificities and alternative ideas that we might not have considered otherwise.

The WKPP integrates Cave Radio Location (CRL), which uses an underground radio transmitter beacon and a surface radio receiver to correct underwater surveys with fixed points. Additionally, their data includes historical references, or “citations,” embedded into the TMLU files to document the origin of survey data, such as logbooks or notes dating back to Sheck Exley.

As a US-based organization, the WKPP also stores its measurements in the imperial system, unlike CINDAQ, which uses the metric system. Working with their data highlighted the need to account for

different Universal Transverse Mercator (UTM) zones when projecting data in ArcGIS Pro — something CINDAQ hadn't needed to address previously.

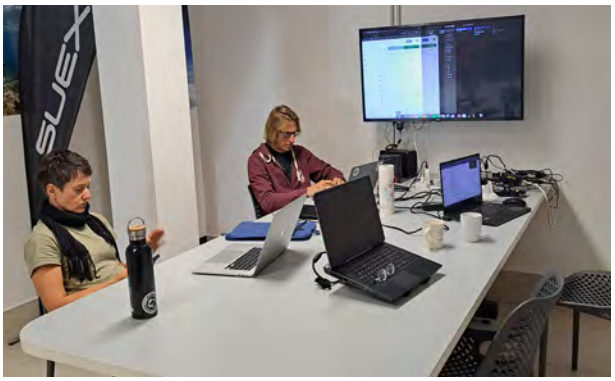
This collaboration not only enabled the WKPP to import their data from Ariane into ArcGIS but also helped the CINDAQ team develop a more robust and versatile tool. The tool can now accommodate a wider range of exploration zones, different field tools, and unit systems, while embedding historical data and supporting multiple versions of ArcGIS Pro.

Collaborative work at its best!

WKPP & CINDAQ COLLABORATION: KEY DEVELOPMENTS

- WORKING FURTHER ON STANDARD COMMENTS
- EMBEDDING METRIC & IMPERIAL SYSTEMS
- INTEGRATING DIFFERENT TIME ZONES
- CONNECTING SURVEY & HISTORICAL DATA
- SUPPORTING MULTIPLE ARCGIS PRO VERSIONS
- BETTER DOCUMENTATION OF OUR PROCESSES

COLLABORATION WITH PHREATIC, SARDINIA, ITALY



In 2023, CINDAQ signed a memorandum of understanding with Phreatic, a not-for-profit organization based in Cala Gonone, Sardinia, Italy. Founded by a group of extreme environment explorers, scientists, and researchers, it is led by our good friend Andrea Marassich. Phreatic and CINDAQ agreed that **collaboration in exploration, scientific diving, documentation, and research** would be mutually beneficial. The goal is to advance shared research interests and co-develop techniques and methodologies.

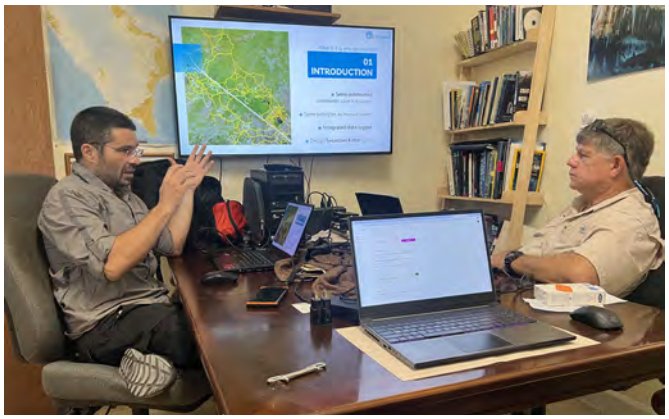
In the fall of 2023, we designed a data management system inspired by the tools already in use at CINDAQ. We helped Phreatic identify the necessary hardware, assisted in setting up their NAS (Network Attached Storage), and centralized their data—previously spread across different platforms—into an organized system.

In May 2024, Julien traveled to Sardinia to collaborate with Andrea on advancing the implementation. This phase focused on identifying Phreatic's exact needs in terms of the types of data being collected, the users requiring access, and the tools and Standard Operating Procedures needed to ensure the data remained clean, secure, and usable.

After several days of work, the Phreatic team had **a comprehensive toolbox for safely accessing their data both locally and remotely**, a double-backup system, and user access and password management utilities. They also began tagging their extensive collection of media related to underwater cave research for both communication and scientific purposes. Furthermore, a roadmap was established for the development of a future GIS system.

It is a pleasure for the CINDAQ team to collaborate with Phreatic, exchanging insights and ideas on exploring and studying caves across two continents. And, of course, there is no denying the joy of working in the beautiful setting of Sardinia!

BAHAMAS CAVES RESEARCH FOUNDATION (BCRF)



From January 26th - February 1st, **Julien and Sam visited Brian Kakuk of the Bahamas Caves Research Foundation (BCRF) in Abaco, Bahamas** to assist with the installation and configuration of hardware and software for a data management system for legacy data collected by the BCRF from 1990-2017.

Data management and security are arguably the most overlooked and underfunded aspects of any organization. **A comprehensive data management system** is not difficult to implement with the right tools and expertise. CINDAQ has been able to design and implement its own data management system to make both existing and new data organized, searchable and usable. With this in mind, we were given the objective by the BCRF to **assist them in implementation of a similar system for their 27 years of legacy data for Bahamian caves**.

Over the 5 days spent on the ground, we were able to accomplish the majority of the tasks we had and still get in 3 dives in the beautiful caves of Abaco. **We look forward to more collaboration with Brian and the BCRF in the future**.

FRENCH INSTITUTE OF PONDICHERRY, INDIA (IFP)

The **French Institute of Pondicherry, India (IFP)** is an institution functionning as an establishment for higher studies and research, reinforcing the Indo-French partnership. The library of the IFP has a rich collection relating to the domains of Indology, Social Sciences and Ecology, consisting of more than 67 000 books, 380 theses, and 1600+ articles. 800 books are added to the collection every year.

A growing amount of very valuable data collected in the field needs to be organized, stored and shared on digital platforms to be used by scientists: **the data challenge faced by the IFP is very similar to the one tackled by CINDAQ in the last few years.**

At the request of Blandine Ripert, the director of the IFP, and Thomas Drouin, researcher, Julien gave a conference at the IFP in June 2024 offering an overview of methods and tools to collect, store and share data for scientific purpose, pulling examples from the world of underwater cave exploration. The methods were then applied by Thomas for his work on the Plantae Malabaricae, a plant collection built around 1733 during the Danish Tranquebar Mission in Tharangambadi, reorganizing his database and images for more efficient analysis and queries.

When the CINDAQ team developed Standard Operating Principles and blueprints for cave exploration data management, **we certainly did not foresee that we would end up helping friends use it for studying palm leaves from a 18th century herbarium!**

MCEP / CINDAQ SCIENCE PROJECT- DECEMBER 2024

Another **successful week of work and fun** for the 19 volunteers from 8 countries who participated in the most recent MCEP / CINDAQ Science Project held at Zero Gravity dive center from Dec 2-7, 2024.

The goals of the Science Projects are to **contribute to a better understanding and appreciation for the caves** and related features by assisting with scientific tasks; all while meeting, mingling and enjoying cave diving with like-minded GUE trained divers. This work contributes to peer reviewed publications and a growing database of cave related knowledge.

The week started with an introduction meeting where **Dr. Ed Reinhardt** highlighted accomplishments from former project work and outlined the plan for current and future research. Chris Le Maillot and Fred Devos explained the tasks and logistics needed to accomplish the established goals.

A **CINDAQ presentation** was given mid-week by **Fred Devos, Julien Fortin, Andreas Rosland** along with GIS specialist **Wetherbee Dorshow** highlighting the 25 year progression of exploration, and data management and utility.

Thank you to all who participated!

KEY FIGURES

- 19 VOLUNTEER GUE DIVERS
- 8 DIFFERENT NATIONALITIES
- 6 DAYS OF SCIENCE WORK
- 2 WATER CHEMISTRY PROFILES
- 14 SEDIMENT TRAPS REPLACED
- 4 HOBO SENSORS DOWNLOADED
- 19 CALCITE LOCATIONS VISITED

ADEX 2024 - SINGAPORE

Sam and Chris attended TekTalk Asia 2024 as part of the **ADEX Ocean Festival** from April 12th to April 14th. Held in Singapore, the ADEX Ocean Festival is an annual event that brings divers together from across Asia and the world. Sam was invited to give a talk on the work of CINDAQ, specifically on our 25 years of exploring in Ox Bel Ha. The conference was a great opportunity to connect and reconnect with many friends and equipment manufacturers and see the sights in Singapore. It is always a pleasure to travel to parts of the world where our good friends are based. **We are grateful for the invitation** and the hard work of the ADEX team, **our good friends Chee Hoon Ong, Gideon Liew, Nora Ismail and Melbin Co** who all made us feel very welcome in their beautiful country.

UNESCO - COLLECTIVE NGO NETWORK

We continued to participate in the working group for the accredited NGOs this year. **Thanks to the leadership of Garry Momber of the Maritime Archaeology Trust** a great deal has been done to move our collective goals forward. In particular, the advance of the UNESCO-accredited NGO initiative, which aims to support the UN Decade of Ocean Science within the Cultural Heritage Framework Program. The project seeks to **leverage the collective NGO network to contribute with the objectives to gather data, raise awareness, and advocate for the protection of underwater cultural heritage**, essentially exploring and documenting the rich history hidden beneath the ocean surface; it's a way to highlight the vast cultural treasures submerged in the world's waters.

The plan includes establishing a number of global hubs for coordination and ongoing fundraising, with CINDAQ possibly serving as a regional NGO hub in the Caribbean. Thanks to Brandon Mason, the UNESCO Underwater Cultural Heritage International Expertise database is now online (*cindaq.org/unesco-ngos*). The website

showcases the work of all of the accredited NGOs and their areas of expertise.

Our work this year in the UNESCO world heritage sites of The Sian Ka'an Biosphere Reserve, Chichen Itza and La Isabella only reinforce our commitment to collaboration between UNESCO, the Scientific Technical Advisory Board (STAB), Federal agencies and expert scientists. We look forward to joining our colleagues in person next June at the UNESCO meeting in Nice, France in order to carry on with this important work.

NOLS WILDERNESS FIRST RESPONDER COURSE

Sam and Julien attended a National Outdoor Leadership School (**NOLS**) Wilderness First Responder (WFR) refresher course in Estes Park, Colorado in September. The two-day class is required to keep the certification active.

As an organization, we believe that keeping our emergency medical skills up to date is important due to the **high risk nature of our work**, and past 'near miss' experiences with minor and major medical emergencies.

The NOLS WFR class is designed for **situations where access to medical care is delayed** or communication is unreliable. It is the industry standard for professional guides, trip leaders, search and rescue team members, outdoor recreationists, and international travelers. As a result, we have refreshed our knowledge and practical skills to conduct a thorough physical exam, obtain a patient history, assess vital signs, provide emergency care in the wilderness, and make crucial evacuation decisions. While we always strive to reduce risk, our participation in this class provides us **peace of mind as we access more remote areas like the Sian Ka'an Biosphere Reserve**.

BFREE DATA MANAGEMENT CONSULTANCY

The Belize Foundation for Research and Environmental Education (BFREE) is a Belizean NGO that strives to successfully integrate scientific research, environmental education, conservation, and create sustainable development opportunities for alternative livelihoods for Belizeans. BFREE was founded in 1995 with a mission "to conserve the biodiversity and cultural heritage of Belize." BFREE leases and manages 1,153 acres of tropical rainforest that lies within one of the largest contiguous tracts of rainforest in the western hemisphere.

Since 2005, Sam has been assisting in research at BFREE and in 2023 joined the board of directors. Upon learning of CINDAQ's data management and GIS capabilities, BFREE's board became interested in seeing how they could **leverage our expertise to create a similar system**.

In early 2024 we presented our system to the board and are working towards a partnership in which CINDAQ provides expertise in the fields of data management and GIS. Currently BFREE is constructing a dedicated space for the hardware necessary which should be completed in 2025. Once it is ready, we plan to be ready to move forward with BFREE and consult with them to **develop a system that best suits their needs**.

2024: THE YEAR IN IMAGERY

Filming in 2024 included intensive efforts in the Dominican Republic, Punta Pajaros and Tuun Ja, along with 10 formal interviews and b-roll surrounding interview subject matter. Additional filming included catalog footage of cenotes, Motmot birds, the halocline, rain and water flow, drone footage, as well as underwater high quality video at Cenote Wakax, Cenote Casa Blanca and Sistema Tuun Ja.

In addition, it has become clear that **CINDAQ can harness the stunning imagery of the cenotes, underwater caves and the exciting related work we do** in order to benefit our relationships with outside partners. Organizations such as Dell, Drone Deploy, SUEX and Ranchbot who support our work can connect their products with our imagery and story to widen their audience reach and highlight how they support CINDAQ. This in turn benefits CINDAQ by **increasing our leverage for expanded support** as well as amplifying our presence and global outreach through this wider audience. We look forward to producing more short videos in the coming months to highlight these important relationships.

In order to increase our output, we recently formalized our collaboration with **Tonatiuh Rangel** in a part-time position to enhance CINDAQ's capacity for capturing above-water imagery and accelerating the release of polished videos. Tona brings with him a **great deal of skills and experience** across the board with video, audio, editing and photography. With the expanded team, we now need an effective collaboration system. In the new year, we plan to set up hardware and workflows to maximize co-editing capabilities and streamline feedback on editing decisions.

VIDEO PROJECTS

Ox Bel Ha

4k stunning imagery of the worlds longest underwater cave .

cindaq.org/obh2024video

UNESCO Project La Isabela

A visual report of the objectives and discoveries during this international project in the Dominican Republic.

cindaq.org/la-isabela

Drone Deploy

The lead-up to the exploration and study of this remote cave system in the sian Kaan Biosphere Reserve.

cindaq.org/drones

Tuun Ja Teaser
(English & Spanish)

The lead-up to the exploration and study of this remote cave system in the sian Kaan Biosphere Reserve.

cindaq.org/tuunja2024eng

cindaq.org/tuunja2024esp

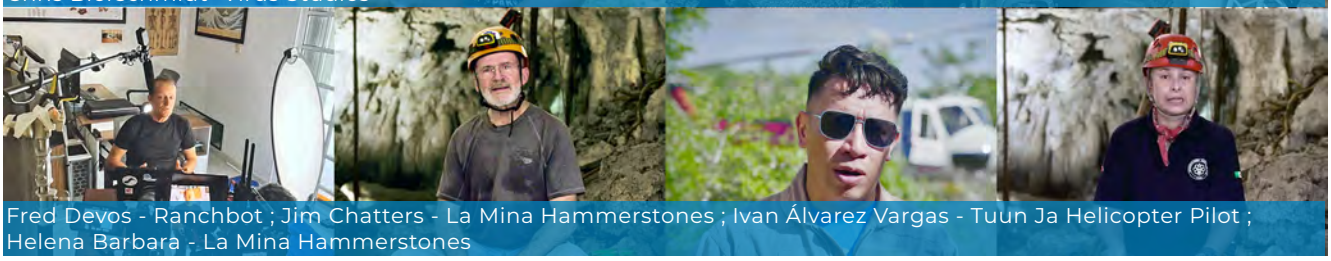
Sagitario Hammerstone
(in production)

Helena Barbara, the head of underwater archaeology in the Yucatan peninsula and leading paleontologist Jim Chatters explain the importance of La Mina and the recent extraction of 3 prehistoric hammerstones now on display in the newly inaugurated musuem in Tulum.

Interviews

Ten formal interviews were conducted in order to provide a more direct connection to the subject matter while maximizing the use of our growing inventory of film equipment.

Juan Carlos Rodríguez Bush - Punta Pájaros ; Nelkis Villaman - UNESCO La Isabela ; Sam Meacham - Ranchbot ; Chris Bierschmidt -Virus Studies



Fred Devos - Ranchbot ; Jim Chatters - La Mina Hammerstones ; Ivan Álvarez Vargas - Tuun Ja Helicopter Pilot ; Helena Barbara - La Mina Hammerstones

PARTNERSHIPS & COMMUNITY ENGAGEMENT

In 2024, CINDAQ continued to develop its **engagement with local committees and collaborative platforms**, sharing our expertise for the sustainable management of the region's water resources. We actively participated in providing scientific and technical advice to municipal and state representatives, always striving for better water resource management in the region.

Our partnership with the **Comisión Nacional de Áreas Naturales Protegidas (CONANP)** remained central to our efforts, especially in the Sian Ka'an Biosphere Reserve. Project reports submitted within the reserve have now reached the highest levels of CONANP, reflecting our deepened engagement. This year, we had the privilege of continuing to explore Punta Pajaros at the invitation from the Punta Pajaros fishing lodge. We also continued to strengthen our relationships with federal partners at **INAH-SAS, INAH-Yucatan Peninsula, and INAH-Mexico City**, with a focus on collaborative efforts in research and conservation.

We are excited to renew our agreement with **Centinelas del Agua** around shared objectives to protect and restore critical water resources in Mexico's Yucatán Peninsula. Through collaborative efforts, including research, conservation initiatives, and awareness programs, we aim to promote a unified approach to protecting the cenotes and underground rivers sustaining biodiversity and local communities. We aim to establish more relationships with organizations sharing common objectives, like Cenotes Urbanos and Cenoteando/UNAM Sisal.

We were honored to attend the 8th Regional Partners Meeting of the **Healthy Reef Initiative for the Mesoamerican Reef System**. We exchanged insights and contributed to joint efforts in protecting the reef and its surrounding ecosystems.

FORUMS AND SYMPOSIUM

We attended the inaugural **Sustainability Forum of Quintana Roo 2024**, themed "Challenges and Opportunities," held on November 19 in Cancun. The event featured panels, presentations, and conferences addressing environmental, social, and economic sustainability issues. Key topics included urban development, beach recovery and protection, water management, coral bleaching in the Mesoamerican Reef, and species conservation, inspiring replication across different business sectors in the state.

We were fortunate to participate in **Reef Futures**, a global symposium dedicated to the actions required to ensure coral reefs thrive into the next century and serving as a hub of hope, action, opportunity, and diversity in the field of coral reef restoration. The symposium provided an invaluable opportunity to reconnect with local, regional, and international partners, fostering collaboration and sharing insights to advance reef restoration worldwide, an effort deeply linked to the conservation of the underground rivers and water of the Yucatan Peninsula.

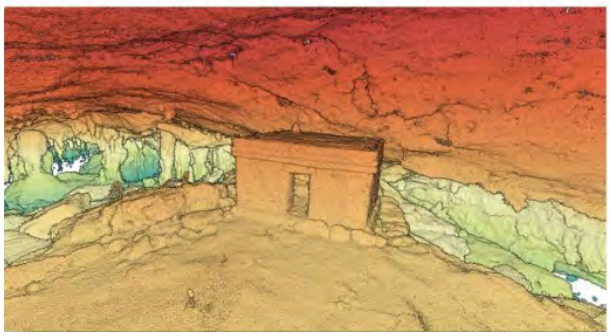
PUBLICATIONS & CONFERENCES

PUBLICATIONS

The following are publications directly or indirectly associated with CINDAQ in 2024:

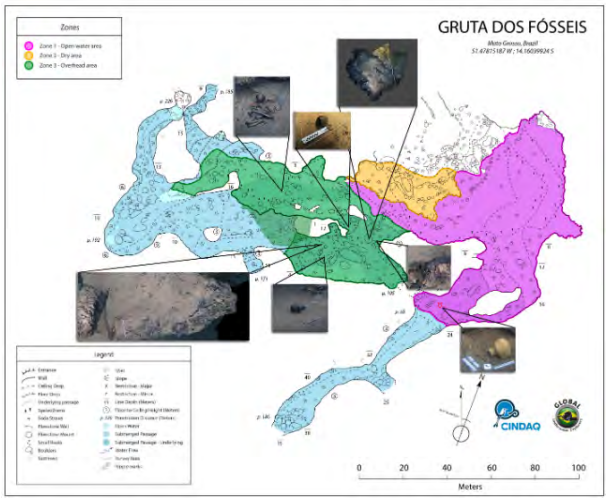
Rissolo, Dominique, Scott McAvoy, Helena Barba Meinecke, Holley Moyes, Samuel Meacham, Julien Fortin, Fred Devos, and Falko Kuester (2024). *A Multimodal Approach to Rapidly Documenting and Visualizing Archaeological Caves in Quintana Roo, Mexico*. The International Archives of the Photogrammetry, Remote Sensing, and Spatial Information Sciences Volume XLVIII-2-2024:349-354.

Hui, Nathan, Dominique Rissolo, and Falko Kuester (2024). *Lighting Model for Underwater Photogrammetric Captures*. The International Archives of the Photogrammetry, Remote Sensing, and Spatial Information Sciences Volume XLVIII-2-2024:153-158.



Menna, Fabio, Scott McAvoy, Erica Nocerino, Beatrice Tanduo, Louise Giuseffi, Alessio Calantropio, Filiberto Chiabrando, Lorenzo Teppati Losè, Andrea Maria Lingua, Stuart Sandin, Clint Edwards, Brian Zgliczynski, Dominique Rissolo, and Falko Kuester (2024). *POSER: an oPen sOurce Simulation platform for tEaching and tRaining underwater photogrammetry*. The International Archives of the Photogrammetry, Remote Sensing, and Spatial Information Sciences Volume XLVIII-2-2024:265-272.

Lo, Eric, Nathan Hui, Hilda Lozano Bravo, Erica Nocerino, Fabio Menna, Dominique Rissolo, and Falko Kuester (2024). *Evaluation of the accuracy of photogrammetric reconstruction of bathymetry using differential GNSS synchronized with an underwater camera*. The International Archives of the Photogrammetry, Remote Sensing, and Spatial Information Sciences Volume XLVIII-2-2024: 211-218.



Sergio Rhein Schirato, Alexandre Jardim, Christophe Le Maillot, Francisco William da Cruz, Eliane Nunes Chim, André Oliveira Sawakuchi, Thays D. Mineli, Ana C. Borella, Haruan Straioto, Andre M. Strauss, Nicolas Stríkis, Luana C. Nicolau, Victor Nery, John Kendall, Julien Fortin, Melissa M. Medina, Rachael Kendall, Samuel Meacham, Susanne Schumacher Schirato, Rodrigo Elias Oliveira (2024). *Early Holocene human occupation in the lowlands of South America- Gruta Azul de Cocalinho, Brazil*. Journal of Historical Archaeology & Anthropological Sciences 9(2):99-108.

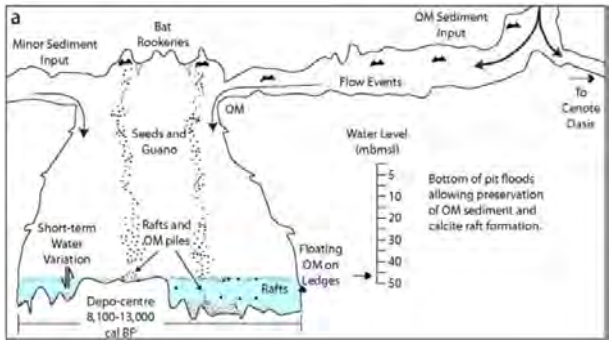
Chatters, James C., H. Gregory MacDonald, Blaine W. Schubert, and Joaquin Arroyo Cabrales (2024). *Cenotes, Caves, and Sloths: Pleistocene Sloth Diversity on the Yucatan Peninsula, Mexico and Belize*, Journal of Cave and Karst Studies

CONFERENCE PRESENTATIONS

Scott P McAvoy, Dominique Rissolo, Travis W. Stanton, José F. J. Osorio León, Francisco Pérez Ruiz, Falko Kuester (2024). *Chichen Itza 3D Atlas: Change Detection, Visualization, and Archival Systems Enabling Multi-Scalar and Multidisciplinary Analysis and Collaboration*. Paper presented at the 30th Meeting of the European Association of Archaeologists, Rome.

PUBLICATIONS & CONFERENCES (CONT.)

Rissolo, Dominique, James C. Chatters, Alberto Nava-Blank, Blaine W. Schubert, Joaquin Arroyo-Cabrales, Vid Petrovic, Keila Bredehoeft, Scott McAvoy, Helena Barba Meinecke, and Falko Kuester (2024). *Recent Advances in Visual Analytics and Virtual Access to Submerged Late Pleistocene and Early Holocene Faunal Deposits in the Submerged caves of the Yucatan Peninsula.* Paper presented at the North American Paleontological Convention, Ann Arbor, MI.



Reinhardt, Eduard G., Shawn V. Collins, Shawn E. Kovacs, Teagan Warkentin, James C. Chatters, Alberto Nava Blank, Sang-Tae Kim, and Dominique Rissolo (2024). *Reconstructing Past Groundwater Levels in Hoyo Negro, Sac Actun Cave System, Quintana Roo, Mexico.* Paper presented at the North American Paleontological Convention, Ann Arbor, MI.

Chatters, James C., Blaine W. Schubert, Joaquin Arroyo-Cabrales, and Dominique Rissolo (2024). *Introducing the Hoyo Negro Vertebrate Fauna, Quintana Roo, Mexico*. Paper presented at the North American Paleontological Convention, Ann Arbor, MI.
Schubert, Blaine W., James C. Chatters, Joaquin Arroyo-Cabrales, Joshua X. Samuels, Leopoldo H. Soibelzon, Francisco J. Prevosti, Damian Ruez-Ramoni, Lars Werdelin, Steven C. Wallace, and Dominique Rissolo (2024). *Exceptional Records of Extinct Carnivorans (Arctotherium, Protocyon, and Smilodon) from Submerged Caves of the Yucatan Peninsula*. Paper presented at the North American Paleontological Convention, Ann Arbor, MI.

McAvoy, Scott, Dominique Rissolo, Travis Stanton, Jose Francisco Osorio Leon, and Francisco Perez Ruiz (2024). *Chichen Itza 3D Atlas.* Paper presented at the 89th Annual Meeting of the Society for American Archaeology, New Orleans, LA.

Rissolo, Dominique, and Patricia A. Beddows (2024). *A Review of Paleocoastal Research on the Yucatan Peninsula*. Paper presented at the 57th Annual Conference on Historical and Underwater Archaeology, Oakland, CA.

Scott P. McAvoy, Dominique Rissolo, Dave Conlin, Brett Seymour, Falko Kuester (2024). *A Visual Archive for 3D Submerged Heritage Data*. Paper presented at the 57th Annual Conference on Historical and Underwater Archaeology, Oakland, CA.

Arroyo Cabrales, J., B. W. Schubert, M. T. Alberdi, V. M. Bravo-Cuevas, E. Jimenez-Hidalgo, S. C. Wallace, C. Widga, and J. C. Chatters. 2024 *Ungulates and Proboscideans from Cenote Hoyo Negro, Quintana Roo, Mexico*. University of Michigan Museum of Paleontology, Papers on Paleontology No 39: 108. Ann Arbor.

Chatters, J. C., H. G. McDonald, B. W. Schubert 2024 *A highly diverse assemblage of giant ground sloths from Hoyo Negro, Quintana Roo, Mexico*. 12th North American Paleontological Convention Program with Abstracts, University of Michigan Museum of Paleontology, Papers on Paleontology no. 39: 145-146. Ann Arbor.

McDonald, H. G., J. C. Chatters, T. J. Gaudin, B. W. Schubert, and J. Arroyo-Cabrales 2024 Update on the extinct sloth Nohochichak and its relationship to Pleistocene sloth diversity of the Yucatan Peninsula. 12th North American Paleontological Convention Program with Abstracts, University of Michigan Museum of Paleontology, Papers on Paleontology no. 39: 303-304. Ann Arbor.

PUBLIC PRESENTATIONS

Jan. Brooks School January Term SCUBA diving class - Remote

Feb. "Taller reflexivo sobre la conservación del sistema hidrológico y arrecifal que da vida a Sian Ka'an" enmarcado en los 38 años de la creación de la Reserva de la Biosfera Sian Ka'an y el Día internacional del Arrecife Mesoamericano - Remote

Apr. ADEX Show

May Ministry of Culture Dominican Republic

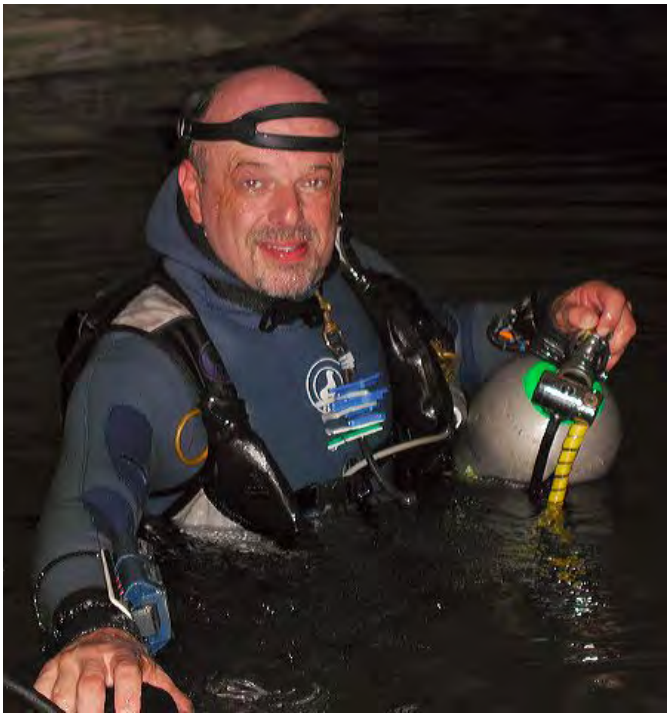
June Institut Français de Pondicherry, India

Sept. Presentation to staff at Punta Pájaros

Sept. Presentation to guests at Punta Pájaros

Nov. The Explorers Club of New York

DEDICATION: BIL PHILLIPS



As we near the completion of the Ox Bel Ha resurvey and expand our efforts into other regional cave systems, it is impossible not to recognize the profound impact that one person had on cave diving exploration in this region. **Bil Phillips was everywhere!**

From our early days working together with Bil at Aquatech Villas DeRosa, we came to know him not only as an accomplished diver (and drummer) but also as someone with a sharp sense of humor and a passion for exploration that matched our own. This shared passion led to the formation of El Grupo de Exploración Ox Bel Ha (GEO) in the mid-1990s and the countless dives and base camps we undertook together, **pushing the boundaries of what we knew about the Ox Bel Ha cave system**.

Now, sadly, Bil is gone, but **his legacy lives on**. As we resurvey the passages of Ox Bel Ha, Sac Actun, and many other caves, we constantly come across his distinctive Mr. Bil line markers—not to mention the occasional fin or knee print nearby, like footprints left by astronauts on the moon.

While we miss Bil and wish we could share our progress with him, we can't help but feel that, in some way, he is still with us, guiding us forward.

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Surfacing Vital Knowledge

If you have any questions, or would like to support us,
please feel free to contact us at **outreach@cindaq.org**

CINDAQ 2024 Report

Fred Devos, Julien Fortin, Christophe Le Maillot
Sam Meacham, Daniel Ponce Taylor, Andreas Rosland

Facilitate research, promote education and support the conservation
of the natural and cultural resources associated
with the cenotes and underground rivers of Quintana Roo, México