CINDAQ
Surfacing Vital Knowledge

2022

CINDAQ 2022 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 2022

Content

EDITORIAL

Surfacing vital knowledge

Motivated by the need to document these cave systems before they are heavily impacted by development

2022 has been a tremendously **productive** year in every aspect of what we do at CINDAQ. As development in and around the Municipality of Tulum and the Sian Ka'an Biosphere Reserve expands and accelerates, so too does our effort to document, study and bring to a global stage the fragile state of our region's aquifer and the crucial role it plays as our freshwater resource and the guardian of significant cultural heritage.

Our **success** stands squarely on our commitment, over the last four years, to carefully examine our processes for data collection and management, then constantly look for ways to improve upon them. With the passing of each year we have become more streamlined, efficient and impactful both above and below the water. This is exemplified by our work in Sistema Ox Bel Ha. At the end of 2018, we began the formidable task of resurveying the entire cave system. As of the end of 2022, we have resurveyed over 233,000 m of existing cave passageways (85% of what we knew to exist when we started); over 86,000 m of that total was done in the last twelve months. As a result of four years of resurvey, more than 115,000 m of new cave passage has been explored in Ox Bel Ha. Tied into the survey data are our observations and documentation of biology, cave navigation, flow patterns, paleontology,

archaeology and many other important features contained within the cave environment. That data, when analyzed and displayed in our Geographic Information System (GIS), allows us to engage the greater scientific community and build further collaborative projects to better understand the complexity and interconnectivity of the aquifer.

We are **motivated** by the need to document these cave systems before they are heavily impacted by development. It is only through their thorough documentation that we can base any effort to monitor and conduct research in them in the future. We are thrilled to announce that two landmark BBC Natural History Unit productions we worked on this year will bring the majesty and fragility of the aquifer to a global audience when they go to air in 2023 and 2024.

> We are only just scratching the surface in revealing the enormous cave networks that underpin this region

We are **motivated** by the realization that we are only just scratching the surface in revealing the enormous network of cave systems that riddle this area. In Sian Ka'an we are planning to begin earnest exploration of the area around Cenote Tuun Ja. We remain convinced that this is an area with enormous potential for exploration and scientific discovery.

We are **motivated** by the ever expanding circle of people that support us, from our donors, sponsors and land owners to the individuals that commit their time and energy to helping us reach our goals. To all of you, you have our **gratitude** for believing in us and sharing an insatiable desire to fully understand how the aquifer of the Yucatan Peninsula works.

Central to the objectives of CINDAQ are the continued exploration of the region's aquifer, support of scientific research and raising awareness. We remain convinced that our actions can bring about the necessary change and awareness to help protect the aquifer of the Yucatan Peninsula before it is too late.

2022

108,153.8 M RESURVEY
38,794.7 M EXPLORATION
146,948.5 M TOTAL

SISTEMA OX BEL HA

Since 2018, the resurvey of the Ox Bel Ha cave system has become **the main focus for the CINDAQ team**. As we are entering our 25th year of work in this vast and complex underwater cave system, it is clear to us that we are working against the clock to collect as much data on it as possible. The continued urban development of Tulum has begun to encroach on Ox Bel Ha and shows no sign of stopping. Some sections of the cave explored by the team during the 2020-2021 field season are now directly under the city. Pristine cenotes that we have known for years are beginning to be impacted negatively.

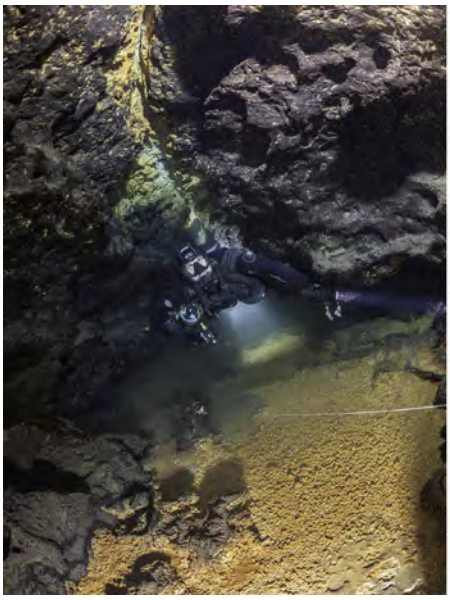
> Working against the clock to collect as much data on Ox Bel Ha as possible

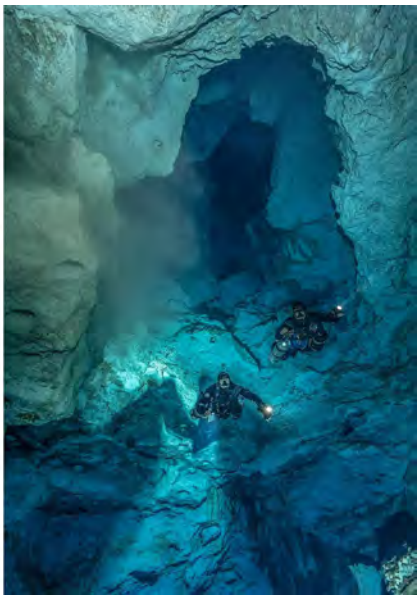
Not only does our team feel privileged to enjoy the cave while resurveying and exploring, but this work is proving to be **a valuable undertaking for many reasons**. As a research group, CINDAQ has access to all corners of the system. This facilitates our effort to expand upon the big picture of Ox Bel Ha's influence, and how it lines up with neighboring caves systems and

development at the surface. We have better tools to do our work more accurately, efficiently, and safely. The MNemo cave survey tool has facilitated the team's ability to more **quickly and accurately collect large quantities of data**, thus accelerating our efforts.

The resulting data has given us **a greater understanding** of key connecting points within the cave system between all major routes thus facilitating our exploration efforts. This is not to take away from all of the efforts made originally by **Grupo**

de Exploración Ox Bel Ha (GEO), the **Mexico Cave Exploration Project (MCEP)**, and **other groups or individuals** that have explored and collected data in Ox Bel Ha over the years. Although all of the original data was collected using just a compass, a digital depth gauge and knotted line, it has proven to be **extremely accurate** when compared with the areas we have resurveyed. These early efforts already showed a great level of dedication and concern for data collection but often lacked consistent observation of the cave environment.





While the line plot data is essential to our understanding of the extent of the cave, it tells us nothing of what is happening inside of it. Improvements in technology with lights, diver propulsion vehicles, rebreathers, the MNemo, and a concentrated focus on data management has allowed us to become better at collecting, storing and interpreting our observational data. Simply put, constant improvements to our equipment allows us to **spend more time underwater**, and **see and do more**. As such, we have begun to focus more on the collection of observational data. With more observational data, we are able to begin to see patterns, whether it is in the distribution of biology or flow patterns across the expanse of the cave. When presented to our scientific partners through our GIS it becomes a powerful tool to engage and plan for future studies.

In 2022, we worked from 7 different cenote entrances, with a particular focus on 2: Cenote Odyssey and Cenote De La Familia.

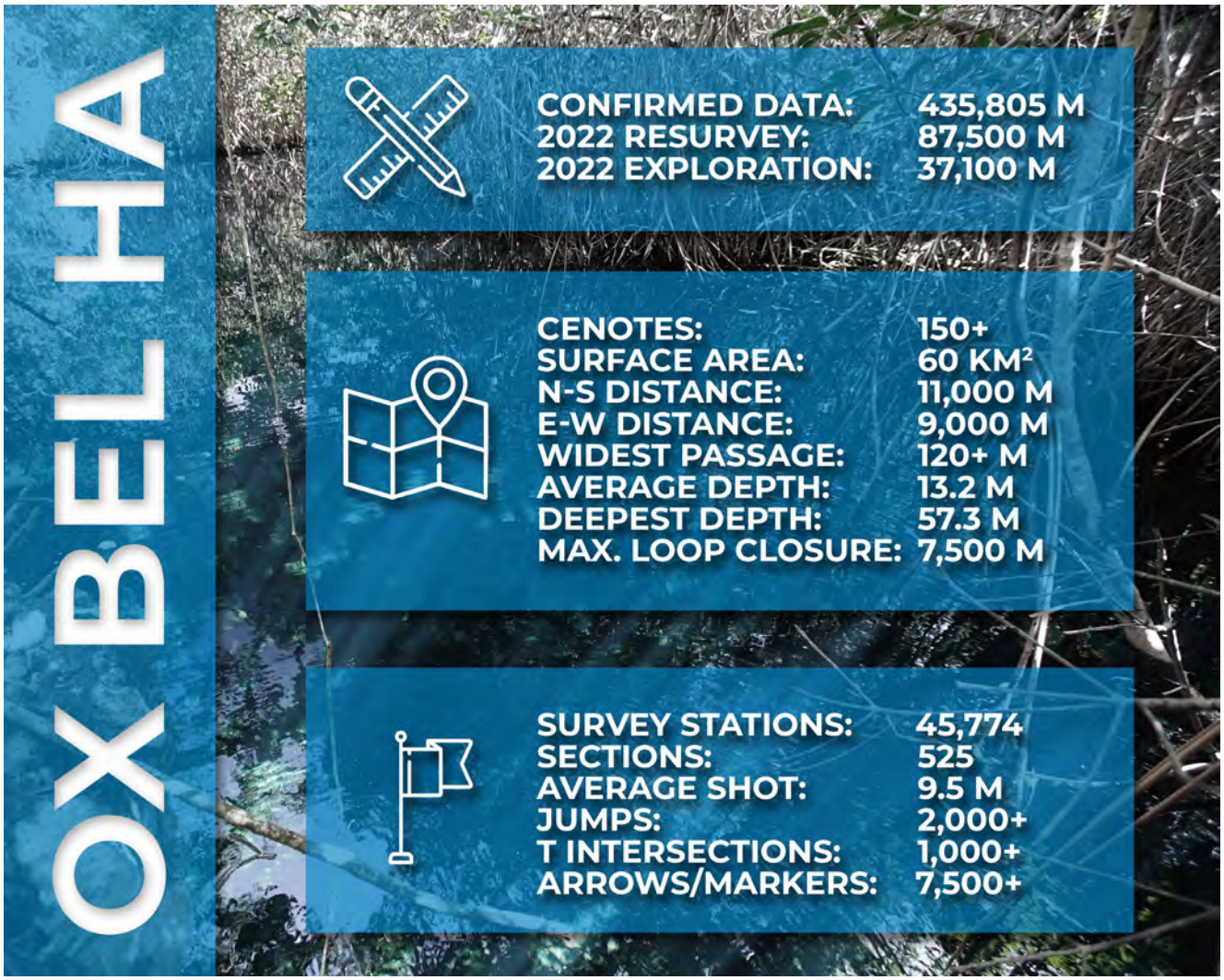
As a result, we were able to surpass our efforts from previous years by **resurveying a total of 87.5 km of line and exploring a total of 37.1 km** of previously unknown passages.

As of the end of the year 2022, Ox Bel Ha now has **a total surveyed length of 435,805 m**.

> “Cave survey: a powerful tool to engage and plan for future scientific studies”

THE MOST DOCUMENTED CAVE SYSTEM?

Giant is the most common terminology that comes up to describe Ox Bel Ha. The dark complexion of most fresh water tunnels through the entire cave system is in total contrast with the whiter, eroded open spaces that can often be encountered in the blue salt water. Ox Bel Ha represents **one of the most diverse and complex cave systems** in Quintana Roo. Thanks to the team’s efforts and improvements to the information gathering process, it may well be the region’s most documented cave system, and a great source of information for any **future scientific studies**.



SISTEMA CRUSTACEA

We only managed to dive this cave twice in a busy 2022 field season. This site is well known for the **large colonies of Remipedia** that live there in the salt water. **Dr. Jil Yager** has published multiple studies about this fascinating troglobite.

Our interests for this cave are twofold:

- It is a great place to **document and capture images** of this elusive creature
- It is the furthest North we have studied on the coast of Quintana Roo, giving us a tremendous opportunity to compare our findings with Cenote Tuun Ja in the Sian Ka'an Biosphere Reserve, 120 km to the South.

We are confident that there will be many **interesting discoveries** from these two unique locations in the coming year.

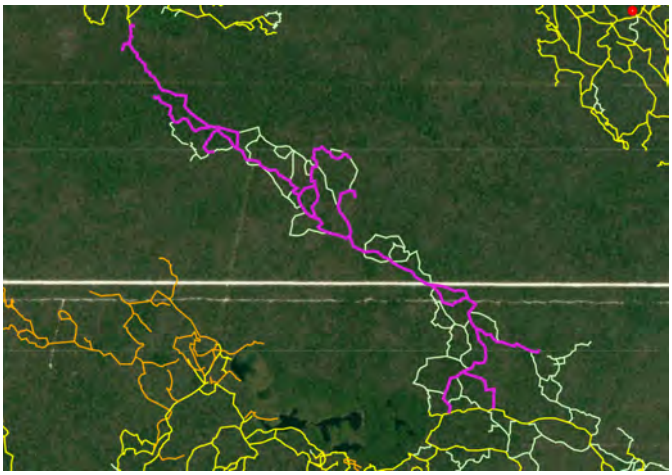
CENOTE FATIMA

Interesting geological oddities discovered along the walls of Cenote Fatima while diving in early February led to a new area of study by **Dr. Eduard Reinhardt**. The team visited this particular cenote for the first time in the **Summer of 2005** as Hurricane Emily hit the coast of Quintana Roo.

Preliminary work included survey and mapping of the cenote's many features down to a depth of 30 m (halocline level). Additional diving in the fall focused on **photogrammetry models of mineral growth and deposits**, and some of the most prominent rock formations.

The team complemented the work in Cenote Fatima by running **multiple water chemistry profiles with our new YSI data sonde**.

EXPLORATION SURVEY DATA USABILITY



Digital data can get messy over time, with duplicate files and folders spread across multiple supports without any standard organization or usable search capabilities. In the same way, the following issues can appear in cave survey data collected over two decades:

1. **The names of the original explorers** of particular cave sections can get lost, through data migration, because the surveyors do not know them, or because the survey software used does not differentiate between explorers and surveyors.

2. For the same reasons, **historical section names** given by the original explorers can be lost as well.

3. Lack of standardization in section names can make it hard to **identify generic regions of the cave**, like the **upstream or downstream** area of a specific entrance, as well as the main passages.

In 2022, a lot of time was invested in cleaning up the entire survey data available in the Ox Bel Ha system: merging sections that could be merged, removing duplicate data, researching the names of the original explorers, line by line, and creating a standard nomenclature for cave sections to allow us to search and display specific areas of the cave, either by known name (cave entrance and/or line name) or cave features (upstream, downstream, **main lines**).

This work allows us to use our **Geographical Information System (GIS)** for **safer dive planning**, more efficient exploration, and to make sure we acknowledge the **crucial contributions of all cave explorers of the region through the years**.

SIAN KA'AN

In March, we returned for one final assessment of Cenote Tuun Ja. We also included a stop over at the Muyil-Xamach forest fire site, which we first visited in early 2021. This third assessment trip was planned in order to **confirm the viability of devoting the time and resources to exploring and studying this area in a more structured way**. In order to do so, we performed another reconnaissance dive, this time to establish and document

> An impressive cave in an area of critical importance: the Sian Ka'an Biosphere Reserve

passageways going upstream to the west/southwest, and to confirm the colder saltwater layer that was observed on the first dive in the fall of 2021.

Julien and Chris were able to cross the large open water section of the cenote, easily find the cave entrance and explore 490 m of cave heading in a straight line to the southwest. The **large cave dimensions** that they found (~20-50 m wide) were similar to the downstream section that was explored the year before. Once again, the depth dropped quickly, with an average depth of 16.1 m, a maximum depth of 34 m and the halocline positioned at 26.2 m. The team observed significant flow which may be an indication of larger passageways further upstream. The **water temperature in the saltwater was 21 °C**, confirming the observations from the year before.

Based on the two dives our team has done, we are confident that there is an enormous potential here for exploration and science.

THE SIAN KA'AN PROJECT SO FAR

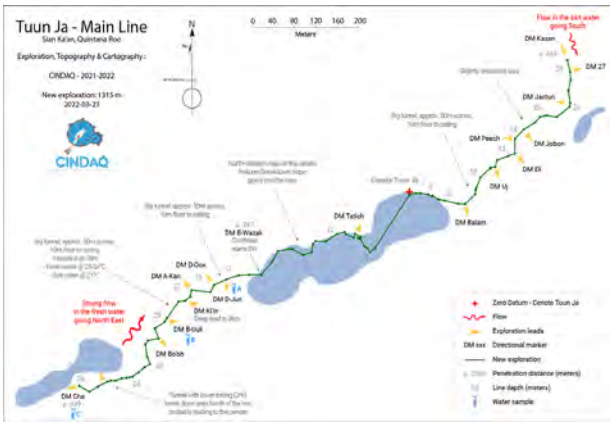
- 3 HELICOPTER FLIGHTS INTO THE ZONA NUCLEO
- FOREST FIRE ASSESSMENT USING DRONES
- TWO EXPLORATORY DIVES IN CENOTE TUUN JA
- 1,315 M OF PRELIMINARY EXPLORATION
- BASE CAMP PREPARATIONS FOR 2023

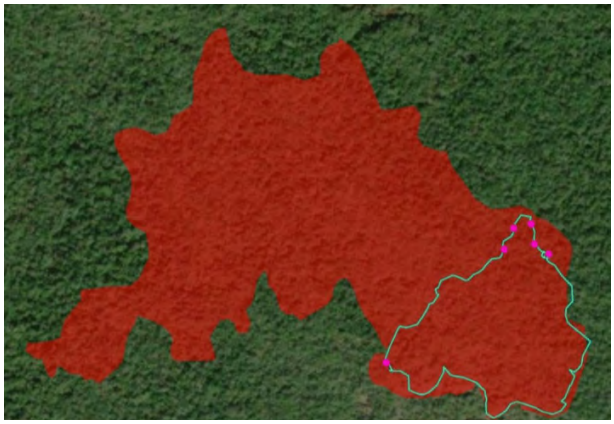
At the surface, and thinking forward to a future base camp, we assessed the use of a larger helicopter for transportation, continued to document the area with photographs and video by using cameras, drones, and **DroneDeploy**, tested a cell phone signal booster to ensure better communications on future missions, and tested a water filtration system to see if the cenote water can be made potable.

Our stop-over at the Muyil-Xamach forest fire site allowed us to fly a DroneDeploy mapping mission in order to compare with previous assessments and to **facilitate CONANP personnel in conducting their own assessments at the site**.

Based on our three trips out to Cenote Tuun Ja, we have concluded that it is definitely of high interest to **pursue a project to explore and study this incredible area**. As a result we have begun to assemble the necessary equipment for our base camp infrastructure. Our goal is to create a base camp that is **technologically advanced but creates minimum impact**.

Once perfected, this infrastructure will allow us to take it anywhere in the reserve to conduct our work.





We expect to return to Tuun Ja in 2023 to open the doors to this new, completely unexplored area of the peninsula.

We are **grateful for the support** we have received from Ecoflow Mexico, Tentsile, Good To-Go and SlingFin as we begin to assemble the necessary pieces of equipment for our base camp project in 2023.

> “Open the doors to this new, completely unexplored area”

CAVE MONITORING

Following up on last year's work, we were further able to **come closer to our goal of live-monitoring the region's aquifer** using the Internet of Things (IoT).

The IoT allows for a **cost-effective way for data to be collected and then transmitted** in small packets from remote locations. Under the guidance of Dr. Richard Wylde and Dr. Eduard Reinhardt, evaluations of two methods are currently underway to determine how to best use the IoT to monitor not only the conditions but also the sensors we have deployed in and around the flooded caves of the area.

The first method utilizes **LoRaWAN protocols to transmit data from a sonar sensor** that measures distance suspended above Cenote Chikin Ha. Data is transmitted from the sensor via a cable to an antenna at the cenote and then on to an antenna located on the roof at the CINDAQ office. This has been successfully running for several months, but more testing is needed to further define the range limits of the system. The LoRaWAN system is perfect in situations where we have line of sight.

The second method utilizes **an autonomous, solar powered base station**. This provides low-bandwidth satellite connectivity using ultra-small satellites in a low orbit. The satellites cover every point on Earth, enabling IoT devices to affordably operate in any location. The autonomy of this system makes it an extremely exciting method for us to employ in more remote settings.

Currently, the base station has been set up and is monitoring water depth in an isolated cenote in the Ox Bel Ha cave system. Our goal is to have a prototype base station array that we can deploy next year in Sian Ka'an.

A lot of work is still needed to figure out how to transmit data from cave-deployed sensors to the surface, but the notion of **having live data streaming in from in-cave sensors throughout a network of caves across the region is very exciting**.

The technology all exists, it is just a matter of putting it all together in a specific package for our environment.

YSI DATA SONDE

As part of our effort to **expand our scientific tool kit**, CINDAQ purchased a YSI EXO1 multiparameter data sonde.

Pressure rated to a depth of 250 m and with sensors to measure depth/temperature, conductivity, pH, turbidity and dissolved oxygen, the YSI probe will give us the ability to capture baseline water chemistry data in any of the caves we work in as well as the ocean environment.

We are excited to be able to **offer this added layer of data to our scientific collaborators**.

It will be especially exciting to record data with the YSI **in the remote cenotes of the Biosphere Reserve** and see how it compares to the caves in other areas. We have already put it to the test in Ox Bel Ha and Cenote Fatima.

UCSD HOVERMAP

In late September, we assisted **Dr. Dominique Rissolo and Scott McAvoy from UCSD and Dr. Holley Moyes of UC Merced** with the proof of concept use of an Emesent Hovermap to rapidly create 3D scans of dry cave entrances in the area.

Hovermap is a smart mobile scanning unit that provides autonomous mapping in challenging inaccessible areas like dry caves. Equally capable above ground or underground, indoors or out, Hovermap provides a complete mobile LiDAR mapping solution.

We had the opportunity to not only try the Hovermap in the 4 main entrances around Sistema Sagitario with **spectacular results**, but also document its use and conduct interviews with Dominique, Scott and Holley.

SAA 2022 - CHICAGO

In March of 2022, Julien, Chris and Sam attended the **87th Annual Meeting for the Society for American Archaeology in Chicago, Illinois**. We had the opportunity to meet with many of our colleagues outside of the field environment, and attend a number of interesting talks on a wide range of topics from maritime archaeology, the ancient Maya, the peopling of the Americas, and the latest technology and methods for archaeological study. Additionally, CINDAQ's efforts were represented in **2 symposia and 4 separate talks**.

STRONTIUM ISOTOPE SNAIL COLLECTION

In May we aided **Dr. Jim Chatters**, CINDAQ affiliate and PI of the Hoyo Negro Project, so he could collect snail shells from portions of the Northwestern Yucatan Peninsula.

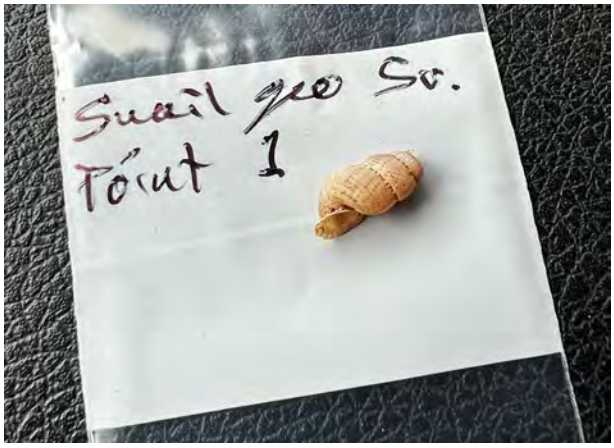
The goal was to **fill a gap in data on the pattern of stable isotope ratios in the northwestern corner of this area.** This gap has previously stymied efforts to publish data on the geographic origin of the 13,000-year-old skeleton known as Naia.

The ratio of Strontium-87 to Strontium-86 varies with the age of rocks. In non marine sediments The Sr^{87}/Sr^{86} ratio decreases with time as the amount of Sr^{86} increases through radioactive decay. Hence, young volcanic rocks have a lower value than older ones. Marine limestones, which comprise most of the Peninsula's rocks are the opposite, increasing in the Sr^{87}/Sr^{86} ratio as the element erodes from older rocks and becomes more concentrated in ocean water. Strontium is taken up by animals, primarily in their food, and is concentrated in bones and teeth. The Sr^{87}/Sr^{86} ratio in such tissues can be used to determine where an individual lived when that tissue was being formed.

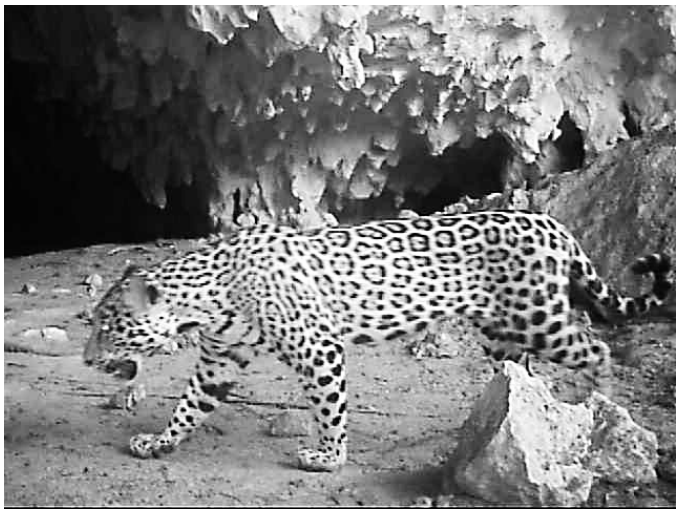
The gap in the northwestern corner of the peninsula made it impossible to rule this area out as a place of origin for Naia. **Strontium ratios can be mapped by sampling water, stone, soil or living things**. When studying strontium to ascertain the geographic origin of living things it is considered preferable to map bioavailable strontium, which is most often measured in the shells of land snails, which are plentiful and easily found. Sam and Jim drove the highways of the northwest peninsula, stopping to gather snails in an approximate grid. All but one of the localities (the first) were open pasture areas, where ground visibility was easy and the snail shells could be obtained in a matter of minutes.

We took care not to collect specimens from road fill to **avoid contamination** by imported rock. In all, we collected 7 sites

between Puerto Morelos and Valladolid and from Playa Del Carmen north to Kantunilkin. As part of the Hoyo Negro Project, which is responsible for the Naia research, samples were submitted to the University of Georgia stable isotopes laboratory for analysis. All 7 produced usable results and, with the exception of a surprisingly low reading for the sample closest to Kantunilkin, **fit the expected pattern of strontium values**.



CENOTE MAMMALS



We are pleased to announce the results of **the four year investigation on the use of cenotes by terrestrial mammals** which were published in May in the journal Biotropica.

The study, which was led by **University of New England (New South Wales, Australia) Professor of Ecosystem Management, Dr Karl Vernes**, and supported by **Fundación Selva Maya** and CINDAQ, confirms the importance of cenotes, and the crucial role they play for our region's diverse population of mammals. The study demonstrated the extensive use of caves by **at least 20 species of terrestrial non-flying mammals**, including pumas and jaguars.

Camera traps monitoring the activity of animals in a number of cenotes in the Akumal region highlight the behavior of the region's local wildlife and the important role that the cenote entrances play in the ecosystem. This was **the first study of mammals using caves in Mexico**, and one of just a few in the world to apply these methods. We truly hope that this study helps to focus attention on the need to protect cenotes as they continue to be threatened by over development in this region.

Please follow this link to download the full publication: **www.cindaq.org/vernes**

HURRICANES AND THE COLLAPSE OF THE MAYA

We are very happy to have played a role in this publication in the journal Nature's Scientific Reports. CINDAQ provided logistical support and helped secure access and permitting to sites that were studied. This marks **our second co-authorship in a high level scientific publication in the last two years**.

Abstract: The collapse of the Maya civilization in the late 1st/early 2nd millennium CE has been attributed to multiple internal and external causes including overpopulation, increased warfare, and environmental deterioration. Yet **the role hurricanes may have played** in the fracturing of Maya socio-political networks, site abandonment, and cultural reconfiguration remains unexplored. Here we present a 2200 yearlong hurricane record developed from sediment recovered from a flooded cenote on the northeastern Yucatan peninsula. The sediment archive contains fine grain autogenic carbonate interspersed with anomalous deposits of coarse carbonate material that we interpret as evidence of local hurricane activity.

Please follow this link to download the full publication: **www.cindaq.org/hurricanes**

UNIVERSITY OF FLORIDA LIDAR

At the end of December, we were paid a visit by **Dr. Jeffrey Glover of Georgia State University**, and his colleagues **Dr. Timothy Murtha, and Dr. Whittaker Schroder of the University of Florida**. Tim and Whit are both at UF's **Florida Institute of Built Environment Resilience (FIBER)** where they investigate the coupled natural human systems dynamics of settlement and land use, relying on advanced geospatial tools such as LiDAR.

Using LiDAR data collected throughout Mexico by NASA Goddard's LiDAR, Hyperspectral, and Thermal Imager (G-LiHT) in 2013, they published their **annotations of thousands of square kilometers** of settlement patterns and natural features in the Maya Lowlands (**www.cindaq.org/uf_landscape**).

Interestingly, the data covers **an area directly above the Ox Bel Ha cave system** and down into the Sian Ka'an Reserve. Soon after their visit, we loaded the LiDAR image into our handheld data collectors and headed into the field to verify whether the annotations of Tim and Whit lined up with the reality of what is there. We were **pleasantly surprised by the accuracy** and the 1 meter resolution on the LiDAR data and how well it lined up with the annotations of Tim and Whit. We look forward to further collaboration with them in the future.

GEOGRAPHIC INFORMATION SYSTEM (GIS)

We continued to **expand and improve upon our GIS throughout the year**. By cleaning our cave line plot data, we have smoothed the process of importation from Ariane and enhanced and improved our ability to visualize and query data.

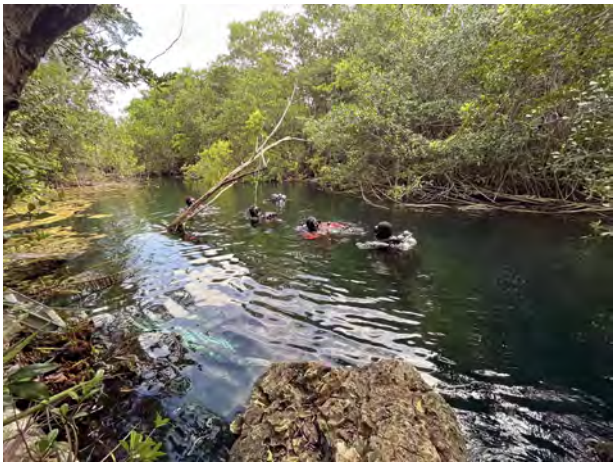
Wetherbee Dorshow spent a week with us in November to work on a number of issues to improve the GIS. Being able **to query our data is a wonderful way in which to begin to see patterns**, which in turn engages our scientific partners. Once we have MOUs in place, we plan to create GIS portals for the institutions and partners we work with, like **INAH SAS, CONANP, UNAM** and other universities.

We are grateful for the continuing support of **Dr. Wetherbee Dorshow** and **Earth Analytic Inc.**

MCEP / CINDAQ SCIENCE PROJECT- DECEMBER 2022

The latest Science Project hosted by CINDAQ and the Mexico Cave Exploration Project (MCEP) was conducted **from December 5 to December 10**. Fifteen volunteer GUE divers from eight countries dedicated their time and skills to facilitate several studies.

Apart from the usual microfossil sediment and algae work, this latest project unveiled a new area of study. **Dr. Eduard Reinhardt** and **his students from McMaster University** in Hamilton, Ontario, Canada have begun to study other cave features in order to better understand the environment and its evolution.



Many advances were made in **CINDAQ's quest to monitor the aquifer** of the Yucatan Peninsula in real time. With **Dr. Richard Wylde**, a physicist and longtime cave diver, experiments were conducted in long range connectivity between sensors in the field and the offices of CINDAQ.

This all relates to the exciting evening presentation given by **Sam and Julien** outlining CINDAQ's advances in the collection, organization and query of a huge and constantly growing data set related to caves and the aquifer.

Future projects are sure to harness these advances and further **facilitate the productive collaboration between GUE divers and scientists**.

During the week, sediment traps were replaced, **water chemistry profiles** collected, depth, conductivity and atmospheric pressure sensors were deployed, and water samples were collected. In addition, numerous videos and **photogrammetry models** were recorded of cave features and their possible biological origin.

SCIENCE WEEK : KEY FIGURES

- 15 VOLUNTEER GUE DIVERS
- 8 DIFFERENT NATIONALITIES
- 6 DAYS OF SCIENCE WORK
- 12 DIFFERENT DIVE SITES
- 7 WATER CHEMISTRY PROFILES
- 10 PHOTOGRAMMETRY MODELS

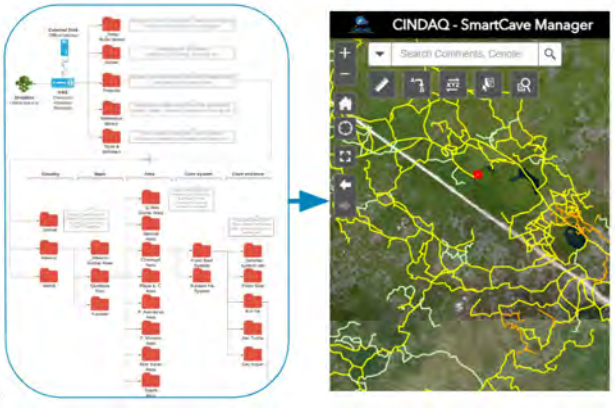
DATA MANAGEMENT

The past few years saw the setup of the new data management architecture, based around a Network-Access Storage. We implemented both automatic online backup and manual offline backup for redundancy, as well as the design of a location-based file storage system into which most of the data from the past 25 years were re-organized. CINDAQ's data management operations in 2022 built on these new tools with 5 main areas of interest:

1. **Improving software and hardware safety**, both in terms of preventing intrusions and avoiding data loss
2. **Extending** the existing system **capacity**
3. **Refining SOPs** and data structures to match ongoing projects after a year of usage
4. **Cleaning up** existing data in a more in-depth and systematic manner to enforce the new file structure and avoid duplicates
5. **Photo-tagging** more pictures, working through the CINDAQ archive of the past 25 years

DATA MANAGEMENT SOPS & TEMPLATES

The daily use of our location-based, standardized data structure by our team, allowed us to make small adjustments to match new applications and projects. We have expanded our data tree to include additional areas and cave entrances, and added standardized directories for new data types (i.e. folders for recordings of assessment videos with scientists, GPS folders for downloading data for specific locations, etc.).



In order to **make the use of the standardized file structure easier for the team**, folder templates have been created and made available on the NAS, which can be copied and pasted in relevant places, with the placeholder names simply edited by users to match the collected data.

DATA CLEAN-UP

A first, generic clean-up was done on the fly while copying the existing data from old external hard disks to the NAS in 2021. We tried to prevent duplicate folders while re-organizing files to match the new structure. Numerous sub-directories and project-specific folders were also copied "as is" and required a second, more advanced analysis.

A semi-automatic duplicate file analysis feature was activated on the NAS, which is running in the background on a daily basis and generates reports that can then be used for manual deletions. Additionally, a more advanced software (Duplicate Cleaner Pro) was installed, configured and used to **track duplicates** in a more systematic manner, resulting in the deletion of almost 2 Tb.

Finally, several "big project" folders were re-organized to match the standardized file structure defined in the CINDAQ SOPs. All of the photogrammetry data on the NAS is now correctly structured, and most of the legacy data organized properly.

CINDAQ DATA : KEY FIGURES

- 20.77 TB (5.5 TB IN 2022)
- 398,400 PICTURES (48,400 IN 2022)
- 18,790 VIDEO FILES (2,290 IN 2022)
- 30,000+ TAGGED PICS (10,000 IN 2022)
- 624,582 FILES & 34,485 FOLDERS
- 3 COPIES OF ALL CINDAQ DATA

PHOTO TAGGING

About **10,000 pictures were tagged in 2022**, not only from this year but also from our 25 years of archives. 100 new keywords were added to the CINDAQ keyword list, for a total of 300 tags.

In addition, **a breakthrough solution for metadata tagging of video footage** was established and is now being implemented.

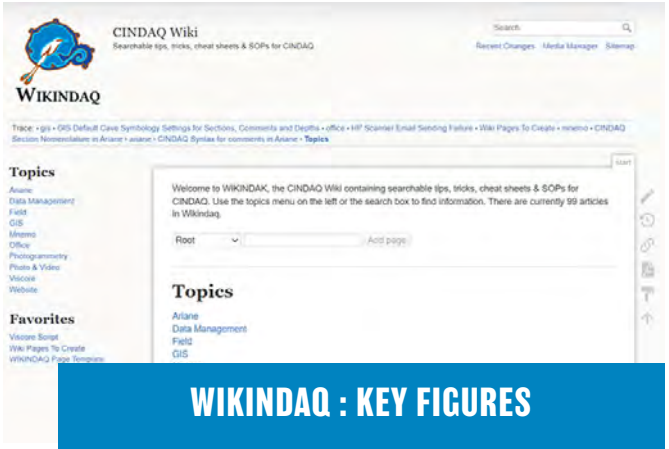
Instead of trying to tag the actual video file, we now take **multiple frame grabs** of the footage and tag these images. Including the original video file name in the frame-grab nomenclature, as well as saving both within the same folder, makes it easy to link the two.

Moreover, these frame grabs allow a visual overview of what the video contains without opening and scrubbing through the large video file. It also makes it **easy to share** just the small JPEG file as a reference instead of initially sending the entire video file.

WIKINDAQ

While 2021 witnessed the creation of numerous SOPs, documents, memos and cheat sheets, that were stored on the NAS, it became clear in 2022 that we needed a better system to organize, access and search this assorted documentation.

With the standardization of our methods and the multiplication of new tools for collecting, processing and storing data, a need also arose regarding the **storing and sharing of instructions and useful information** for using these tools efficiently.



WIKINDAQ : KEY FIGURES

- 100+ ARTICLES
- 10 CATEGORIES

The new system had to be **light-weight, easy to update, easy to access** both from the office and in the field, **searchable**, and allow for **cross-referencing** between the different documentations. As Wikipedia is the closest existing system meeting all these requirements, the CINDAQ team decided to create a Wiki specifically dedicated to all documentations, SOPs, tips, tricks and methodologies of CINDAQ: WIKINDAQ was designed and implemented mid-2022, and has grown to **a system of over 100 articles** by the end of the year.

The team can now search through an entire, specialized knowledge base for executing common data collection or processing tasks. We can also look for **solutions for commonly encountered problems and frequently asked questions** in areas as diverse as photogrammetry, survey data entry, office work, data management, or inventory.

UNESCO

We have agreed to be part of a 'working group' subcommittee to help steer the direction of the accredited NGOs under the guidance of Chris Underwood of the International Council on Monuments and Sites' International Committee on the Underwater Cultural Heritage (ICOMOS ICUCH). We participated in a number of subcommittee meetings and full member meetings. We contributed information about CINDAQ and our activities to the **Maritime Archaeology Trusts UNESCO Underwater Cultural Heritage International Expertise database**. The database provides a clear link to the activities and expertise of all the UNESCO UCH accredited NGOs.

We look forward to continuing our participation in the coming year and, hopefully, meeting some of the other NGOs in person.

MEETINGS

2022 saw the re-start of face-to-face local and regional meetings and workshops. We are **grateful to once again meet with our partners, key stakeholders, and local elected officials**, and to explore future partnerships and collaborations.

> To help create strategies and working documents that can be shared with local, state and federal institutions and stakeholders

The meetings and workshops we attend are valuable as they allow us to interject our thoughts and expertise into the discussions that take place.

Our objective is to help create strategies and working documents that can be shared with local, state and federal institutions and stakeholders. This ensures that our data is used where needed for the **conservation and sustainable management of the region's aquifer.**

Unfortunately, due to restrictions still in place because of the pandemic and changes in the Municipal governments of Tulum and Solidardidad, there were no municipal committee meetings this year.

This year we began to **formalize some of our long-standing partnerships**, with institutional collaboration agreements.

We are happy to announce a formal memorandum of understanding between CINDAQ and the **University of California San Diego**.

We are currently working on similar agreements with **UNAM, McMaster University, CONANP and INAH**, all of which we hope to formalize in the coming months.

We remain committed to being a proactive member of these networks and committees, sharing our expertise and findings, as well as exploring new partnership opportunities.

COMMITTEE PARTICIPATION 2022

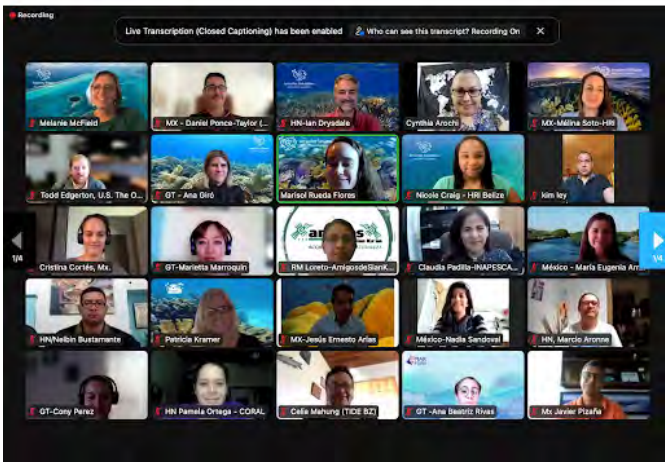
- HEALTHY REEFS FOR HEALTHY PEOPLE
- QUINTANA ROO'S COASTAL POLICIES DOCUMENT

HEALTHY REEFS FOR HEALTHY PEOPLE

The Healthy Reefs for Healthy People Initiative was launched in 2003 on the premise that **healthy reefs are essential for sustaining healthy people**. In turn, only when local people are healthy and thriving can they be expected to protect the reefs and other natural resources upon which their livelihoods and quality of life depend.

The main goals of this initiative are to:

- **Promote the adoption & application of Healthy Reefs indicators** by managers, policy makers & other leaders for the integrity of the Mesoamerican Reef Ecosystem
- **Standardize the analysis and interpretation** of **reliable scientific data** to improve reef ecosystem management
- **Serve as an open forum** for information sharing and networking among science and conservation partners.



The Healthy Reefs for Healthy People Initiative **encourages dialogue and collaboration** to strengthen efforts to protect the Mesoamerican Reef. CINDAQ attended several Healthy Reef meetings and workshops during 2022. In February all partner organizations met in order to start analyzing the collected data and discuss how to present the 2022 report, as well as to restart the pre-COVID annual partner meeting, where all partners get together and discuss the outline, priorities and main message for the annual report card.

In December we attended a **Healthy Reefs for Healthy People** workshop for its Mexican partners. This was the unofficial presentation of the 2022 Mesoamerican Reef Health Report Card. This was **the first time the final report was shared** and all partners were given copies to share with their staff and communities. We are happy to have participated in this and are glad to see emphasis being placed on the watersheds that feed into the reef system. We are saddened that the overall report continues to show an ongoing decline on reef health indexes in Mexico and the wider region.

www.cindaq.org/healthyreef_2022

QUINTANA ROO'S COASTAL POLICIES

Over the last year and a half, the **State of Quintana Roo** developed a series of workshops and public events in order to create Mexico's first integral coastal policy for our Caribbean Coastline. The effort, led and coordinated by **Mr. Alfredo Arellano**, resulted in the official publication of the document by the Quintana Roo State government in September of this year. We are proud to have contributed to this monumental effort.

www.cindaq.org/costas_qr2022

Related to this process, we attended the session on "**Transboundary diagnostic analysis for Mexico**". This informative meeting had the objective of bringing together experts, key regional and national stakeholders, and local NGOs, to allow for feedback on the studies and analysis done so far. This was a good networking event and gave a good indication of potential relevant organizations to work with in the future.

BBC NATURAL HISTORY UNIT SHOOTS

For five weeks in April and May the entire CINDAQ team worked on **two landmark BBC Natural History Unit films**. These two wildlife documentaries will go to air in 2023 and 2024.

The Natural History Unit is part of BBC Studios, a subsidiary of the BBC, which develops, produces and distributes bold, breathtaking content, making **over 2,500 hours** of content annually, operating in **22 markets** globally and reaching an audience of **hundreds of millions of viewers**.

It was a pleasure once again to work with the NHU, and **Mike Madden** who was key to making this project happen despite delays caused by the pandemic. A benefit of the delays was that it allowed us to further build our inventory of camera and lighting equipment and to refine our underwater filming techniques. Principal among these was the acquisition and use of the SUEX Zero Frame camera harness which allows us to capture smooth long shots through the cave environment. We were also able to acquire an array of Keldan video lights that allow us to illuminate the cave in dramatic fashion. Thanks to Mike's guidance during the pandemic we gained experience and confidence as a team, making us more efficient and productive once the shoots finally began. This was no more evident than when Mike fell ill and **Fred was able to seamlessly step in** and take over the camera operation for the duration.

We also enjoyed working again with **Scott Carnahan** who was there to ensure everything ran smoothly at the surface. We are all very excited to see the final products and share the message of cave awareness and conservation that is core to CINDAQ and that landmark series like these bring to a global audience.

JP BRESSER SHORT FILMS

We were happy to spend time with **our good friend JP Bresser** in February and March as he continued his many years of documenting our work in this area.

On this trip, JP took Chris, Fred, and Sam aside and interviewed each of them about **meaningful dives** that we have done over the years. Chris focused on his early work in and around Cenote De La Familia, Fred on his love of Cenote Otoch Ha, and Sam on his first dives from Cenote Esmeralda.

The first video on Esmeralda is out, and JP expects to have the others out in 2023. Thank you JP!

www.cindaq.org/jp_esmeralda

VIDEO DOCUMENTATION

2022 was a time to **raise the quality and quantity of video documentation**. We spent many hours both underwater and on the surface capturing imagery to go along with the interview dialogue. Much of the footage focused on specific topics related to CINDAQ's partnerships as well as internal work.

For each of these subjects, the footage has been compiled and a first pass edit completed. Multiple audio tracks and cameras are now synchronized on a timeline and unneeded footage has been cut.

The remaining footage with dialogue has been transcribed and time coded in order to **allow easy use of particular sections in multiple edited storylines**. This is geared towards a workflow for external editing that allows Fred to focus more of his time on collecting the raw footage both above and below the water.

We were fortunate to spend time with Mark Chesak, a long-form documentary editor, with 40 years of experience. He spent 4 days with Sam and Fred during which we covered the planning, filming and first pass edit of a short video highlighting CINDAQ's use of **Drone Deploy** software. Spending time with Mark helped us to begin focusing

on how to better document our activity and the related environment, and also maintain control over the vision and use of finished videos. Further refinement is still needed but once a template has been developed we will begin to release a series of short videos.

These videos will not only complement any scientific publications we are a part of, they will also provide a means to **promote CINDAQ's efforts to a wider audience**.

The small German film production that Fred worked on in 2021 aired on **ARD1** in Germany this spring. The show, named **Waterwoman**, follows acclaimed freediver **Anna von Boetticher** as she travelled through our area experiencing its many aquatic environments. The program looks at the importance of water to the world around us, how it shapes the natural environment as well as how we interact with it as humans. Fred took her to Cenote De La Familia in Ox Bel Ha and was able to capture some breathtaking scenes.

www.cindaq.org/waterwoman

A lot of effort was also put into providing footage for two short promotional videos being produced by **SUEX**. More than 600 GB of 4k footage including interviews, underwater imagery, drone footage and B-roll was provided to **SUEX**.

The storyline will highlight CINDAQ's efforts and use of scooters over the years. These videos will be edited by **SUEX** and distributed in 2023.

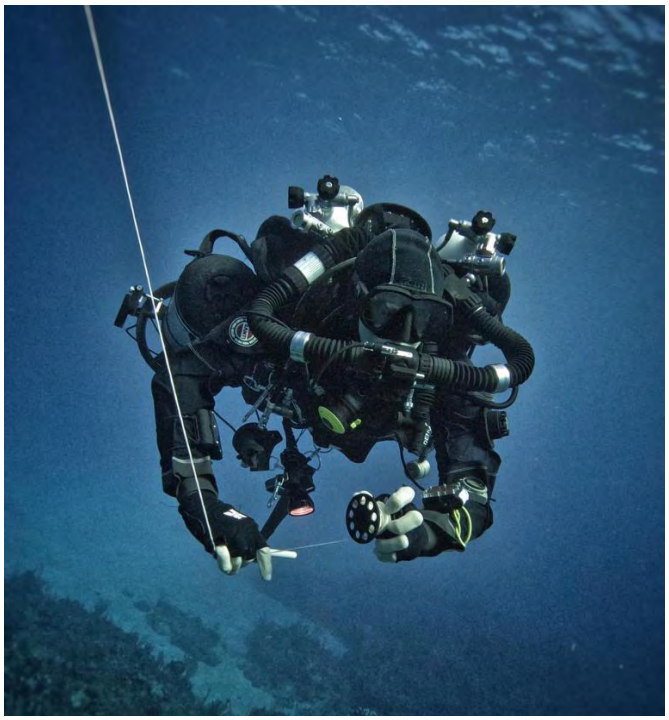
NOLS WILDERNESS FIRST RESPONDER COURSE

Due to the high risk nature of our work, and past 'near miss' experiences with both minor and major medical emergencies, Sam and Julien participated in a 10-day **National Outdoor Leadership School (NOLS), Wilderness First Responder (WFR) course** in Orlando, Florida in January.

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. We have also **invested in robust first aid supplies for our field work**. 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. We are grateful to our instructors **Jason Carter and Sarah Acuff,** as well **Joe Yuska** from **Lewis and Clark College** who organized and facilitated the course.

CLOSED CIRCUIT REBREATHER (CCR) COURSES



We received **training on two different closed circuit rebreather (CCR) units** this year. This is part of an effort to evaluate their efficacy and use on future projects.

CCRs provide many advantages, not least of which is their ability to **conserve a significant amount of gas used on each dive**. This is of particular relevance in more remote areas like Cenote Tuun Ja in Sian Ka'an where every breath of gas will count.

We evaluated the back mounted JJ CCR and the side mounted KISS Sidewinder, both well known units in the realm of technical diving. We are still undecided on which unit we will choose in the end. There are still one or two more units that we are interested in trying.

We are grateful for the time and effort of **JP Bresser** and **Sabine Sidi-Ali** who provided the training to us.

NEXT GENERATION TOOLS WORKSHOPS

Julien and Sam were **invited to Florida in October by Global Underwater Explorers (GUE)** to give a workshop on the MNemo and Ariane.

The 2-day workshop has been **designed by CINDAQ to introduce divers to the basic operation of the MNemo and its interface with Ariane**. The workshop was very well received by the seven participants and GUE instructors who observed. An additional workshop was done for 5 participants in late December here in Mexico.

Even though most of the participants were already familiar with the use of the Mnemo, the workshop provided an excellent opportunity for us to share even more information on its use, maintenance and inner workings.

We look forward to using this workshop in the future as a way to supplement income for CINDAQ and to **onboard new team members**. We envision the class as **a springboard to continue data collection** on the region's cenotes and cave systems and to engage our volunteer divers.

CINDAQ WORKSHOPS: KEY FIGURES

- CREATED A MNEMO WORKSHOP
- CREATED AN ARIANE WORKSHOP
- CREATED A DATA WORKFLOW WORKSHOP
- CREATED SUPPORTING MATERIALS
- 2 WORKSHOPS DELIVERED (FLORIDA/MEXICO)
- 12 PARTICIPANTS TRAINED

OTHER CONSULTING PROJECTS

An unintended but welcome result of our work has been that other, similar, projects from around the world are seeking our advice.

Over the last year, we have continued to consult with **Phreatic**, an Italian NGO working in Sardinia, the **Woodville Karst Plain Project (WKPP)** in north Florida, and the **Bahamas Caves Research Foundation (BCRF)** based in Abaco.

We are happy to share our knowledge and to learn from these other world class projects as well.

It was an absolute pleasure to welcome **Brian Kakuk**, the director of BCRF here in the fall, and take him on a survey dive.

We anticipate **even more collaborative efforts** with these projects and others in 2023.

INTERVIEWS

We continued with our effort to **record short interviews with the scientists and partners** we work with, as well as our **team members**. By doing so, we are able to highlight the important research being conducted, and the role that CINDAQ plays in this work.

When publications are submitted, our collaborators will have ready made videos and images to accompany them. We improved our sound capture and surface lighting capabilities to improve the quality of the interviews we conduct.

This year we were able to shoot **a total of 21 interviews** that cover a wide range of topics. We look forward to beginning to produce short videos in 2023 with all of the material we have collected.

MARKETING & COMMUNICATION

Under the guidance of **Gavin Greenwood and Nacho Prado**, CINDAQ carried out an internal process to **review our current corporate image**, including our logo. After several meetings and discussions, and many drafts, a new logo, tagline, and corporate identity was unveiled. This new brand takes the legacy and recognizable features from the old logo into a newer, cleaner design.

Beginning in 2023 we will begin to develop a **communications strategy** and specific branded merchandise. One of the first steps for communication is the development of a new website, currently being designed by **Gopadma Technologies**. The website is being designed to present CINDAQ's work in a more organized and professional manner. Overall, our new corporate image will allow us to **consistently communicate across all of our platforms**.

PUBLICATIONS & CONFERENCES

PUBLICATIONS

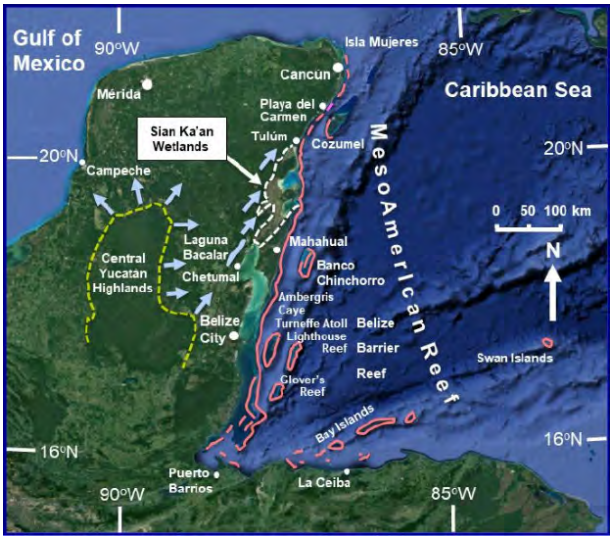
The following are publications directly or indirectly associated with CINDAQ in 2022:

Arellano-Guillermo, Alfredo & Benito, Rafael & Madrigal, Silvana & Albuerne, Adriana. (2022). *Política de Costas del Estado de Quintana Roo, México*.

www.cindaq.org/costas_qr2022

Glover, J., Rissolo, D., Beddows,P., Jaijel, R, Smith, D., Goodman-Tchernov, B. (2022). *The Project Costa Escondida: Historical ecology and the study of past coastal landscapes in the Maya area*. The Journal of Island and Coastal Archaeology. 10.1080/15564894.2022.2061652.

www.cindaq.org/costa_escondida



Platt, N., Wright, V. (2022). *Flooding of a carbonate platform: the Sian Ka'an Wetlands, Yucatán, Mexico – a model for the formation and evolution of palustrine carbonate factories around the modern Caribbean Sea and in the depositional record.* The Depositional Record. 10.1002/dep2.217.

www.cindaq.org/platt

Prieto Hernández, D., et al. (2021) México. *Grandeza y Diversidad National*. Institute of Anthropology and History ISBN 978-607-539-498-5

www.cindaq.org/mexico_grandeza

Rojas Sandoval, C., Covarrubias Reyna, M., Rissolo D. (2022) *Constructing a World Beneath Quintana Roo*. Constructing Space: Causeways, Walls, and Open Areas in the Ancient and Historical Maya Landscapes, edited by Thomas Guderjan and Jennifer Mathews. Tucson, University of Arizona Press.

Steele, R.E., Reinhardt, E.G., Devos, F. Meacham, S., LeMaillot, C., Gabriel, J.J., Rissolo, D., Arturo Verad, C., Peros M.C., Kim, S.T., Cumming, B., Marshal, M., Zhua, J., submitted, *Sediment accumulations from Boca Paila Cave, Sian Ka'an Biosphere, Mexico, provide evidence on recent sea-level rise and the formation of a Classic Maya canal system*. Quaternary Science Reviews.

Sullivan, R.M., van Hengstum, P.J., Donnelly, J.P., Tomalavage, A.E., Winkler, T.S., Little, S.N., Mejia-Ortiz, L., Reinhardt, E.G., Meacham, S., Schumacher, C. and Korty, R., (2022). *Northeast Yucatan hurricane activity during the Maya Classic and Postclassic periods*. Scientific Reports, 12(1), pp.1-11

www.cindaq.org/hurricanes

Vernes, K. & Devos, F. (2022). *Use of cenotes and the cave environment by mammals on the Yucatán Peninsula, Mexico*. Biotropica, 54, 881– 892.

www.cindaq.org/vernes

PUBLICATIONS & CONFERENCES (CONT.)

CONFERENCE PAPERS

Rissolo, Dominique, Jeffrey B. Glover, Roy Jail, Beverly Goodman, and Patricia A. Beddows
(2022) *The Hidden Coast of Northern Quintana Roo: Paleoenvironmental Reconstruction of the Ancient Maya Port Site of Vista Alegre*. Paper presented at the 87th Annual Meeting of the Society for American Archaeology, Chicago, IL.

Pryzbyla, Joy, Dominique Rissolo, and Jeffrey B. Glover (2022)
Chen Mul Modeled Effigy Censers, Maya Caves, and their Relationship with Ritual Practices: Evidence from the Central Coastal Region of Quintana Roo, Mexico. Paper presented at the 87th Annual Meeting of the Society for American Archaeology, Chicago, IL.

Glover, Jeffrey, Emma Slayton, and Dominique Rissolo
(2022) *Modeling Ancient Maya Long-Distance, Canoe-Based Trade around the Yucatan Peninsula*. Paper presented at the Computer Applications in Archaeology Conference, Oxford, UK.

Rissolo, Dominique, Corly Huang, Qiming Chen, Vid Petrovic, Alberto Nava Blank, Helena Barba Meineke, Falko Kuester, and Leanne Chukoskie (2022)
Development of a Learning Game for the Submerged Ice Age Site of Hoyo Negro, Mexico. Paper presented at the 55th Annual Conference on Historical and Underwater Archaeology, Philadelphia, PA.

Steele, R., Eduard Reinhardt, Fred Devos, Samuel Meacham and Dominique Rissolo (2022)
A 3,000-Year History of Coastal Landscape Evolution from Boca Paila Cave Sediments Provides Evidence on the Formation of a Classic Maya Canal System in the Sian Ka'an Biosphere, Mexico.
Society of American Archaeology Annual Meeting, Chicago, Il., USA, March 31st – April 3rd, 2022.

87TH ANNUAL MEETING SOCIETY FOR AMERICAN ARCHAEOLOGY, CHICAGO, IL., USA

Session:
Conducting Paleoindian Archaeology in the Submerged Caves of the Yucatan Peninsula

Organizers:
James C. Chatters, Dominique Rissolo

Chair:
James C. Chatters

Evidence of human activity of apparent Paleoindian age is being increasingly found in the ~ 2000 kilometers of flooded cave systems of the state of Quintana Roo, Mexico. More than a dozen skeletons presumed to be of this age range have been found. Extensive mining activities, focused on ochre, have been documented in multiple systems and represent intensive, prolonged labor deep within the tunnels. The environment where these discoveries are being made—located far from entrances, in darkness with overhead and under-foot hazards, submerged for at least 5 millennia in carbonate-rich often

PUBLICATIONS & CONFERENCES (CONT.)

saline waters, and in tropical temperatures that accelerated chemical changes and organic decay—poses immense challenges to documentation, specimen recovery, conservation, and interpretation. Participants in this session, who include cave divers, software designers, engineers, geo archaeologists, and dating experts share the solutions they have developed for working in this unique setting and some of the findings they have achieved.

Helena Meinecke, Diana Recio, Abiud Pizá, Germán Yáñez and Gabriel León
Underwater Cultural Heritage in the Karst Systems of the Yucatan Peninsula: The Role of the Atlas of Caves and Cenotes, SAS INAH

Samuel Meacham, Julien Fortin, Wetherbee Dorshow, Christophe Le Maillot and Fred Devos
From Underwater Cave Survey in Yucatan, Mexico, to Geographical Information System (GIS): Concrete Case Study and Replicable Workflow Linking Data Acquisition to Scientific Data Exploitation

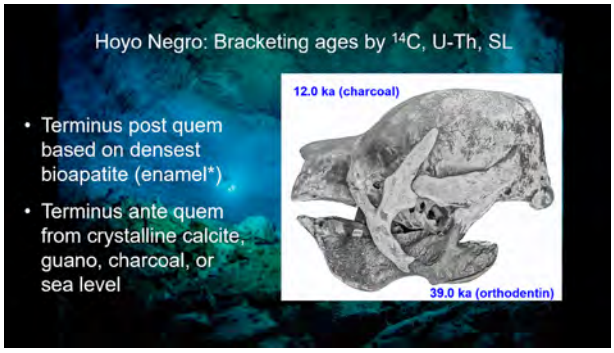
Eduard Reinhardt, Brandi MacDonald, James Chatters, Samuel Meacham and Dominique Rissolo
Paleoindian Ochre Mines in the Submerged Caves of the Yucatan Peninsula, Quintana Roo, Mexico

Vid Petrovic, James Chatters, Dominique Rissolo, David Zollinger and Blaine Schubert
Combining Virtual and Physical Fieldwork: The Recovery of a Submerged Ground Sloth Synsacrum from Hoyo Negro

Alberto Nava, Alejandro Alvarez, Roberto Chavez Arce, Samuel Meacham and Helena Barba Meinecke
Skeleton Recovery Technique for Deeper Underwater Caves

Diana Arano Recio, Keila Bredehoeft, Dominique Rissolo, Alberto Nava Blank and Helena Barba Meinecke
Archaeological Conservation in the Submerged Caves of the Yucatan Peninsula: The Case of Prehistoric Human and Faunal Remains in Hoyo Negro, Mexico

Barrett Rock and James Chatters
Analysis of Wood Cellular Structure in Early Holocene Charcoal Fragments from the Yucatan Reveals Post-Glacial Human Activity and Forest Composition



James Chatters, Patricia Beddows, Eduard Reinhardt, Juan Pablo Bernal and John Southon
Radiometric Dating in the Submerged Caves of the Yucatan Peninsula

PUBLIC PRESENTATIONS

Jan. Lewis & Clark University students and other participants in Wilderness First Responder Class, Orlando, Florida, USA

Jan. Employees of Halcyon MFG, High Springs, Florida, USA

Feb. Institut Français, Pondicherry, India

Mar. Eastern Carolina University Program in Maritime Studies, Greenville, North Carolina, USA

Apr. The Society for American Archaeology Annual Conference, Chicago, Illinois, USA

Jun. Mount Tamalpais School, Mill Valley, California, USA

Sept. Marine Estuarine and Freshwater Biology Seminar at The University of New Hampshire, Durham, New Hampshire, USA

Oct. Keynote address to the the 2022 Drone Deploy Conference, Dallas, Texas, USA

Oct. GUE Project Diver Program, Extreme Exposure, High Springs, Florida, USA

Dec. MCEP/CINDAQ Science Project, Puerto Aventuras, Mexico

DEDICATION: JEREMIAS & JOSE LUIS HERNANDEZ

Many people look at what we do and only see the diving. What they may not see is **the hard work that goes on behind the scenes** to enable us to do what we do. For even one dive, there is **a tremendous amount of logistical support** involved. Multiply this by the hundreds of dives we do each year and it is obvious that we could not achieve what we do on our own.

For us, the concept of teamwork starts at the surface, and we are blessed to have the combination of **Jeremias and Jose Luis Hernandez** there to provide us with this critical support. For over three years Jeremias and Jose Luis have looked after us with a high degree of skill, caring and good humor. More than that, they have become **good friends to us all**. Without their support, we would not have been able to do half of what we have done over the years.

It is with sincere gratitude that we dedicate this report to them.

AKNOWLEDGEMENTS & THANKS

We are grateful for the support we received in 2022 from:

Dr. Robert Lourie

Mr. Rami Shakarchi, PGA Tour and the World Wide Technology Championship at Mayakoba, Mr. Joe Mazzeo, The Strauss Family Foundation, Beth and John Storyk, Mr. Brian Strauss, Mr. Rick Guerin, Mr. Michael Ortiz

DroneDeploy, Zero Gravity Dive Center, Halcyon MFG, SUEX, Reef Photo and Video, Nauticam, Gignet, Good To-Go, Ecoflow Mexico, Tentsile, Microsoft Corporation, Agisoft, Google, Dropbox, SlingFin

Jeremias & Jose Luis Hernandez
Benjamin Meacham

El Ejido Jose Maria Pino Suarez
Ing. Antonino Almazán
Ing. Miguel Pérez
Hectór Huesca

The Friends of Mexican Development Foundation
Emily Grand

INAH SAS
Dr. Roberto Junco Sanchez
Dr. Silvina Vigliani

INAH Yucatan
Arq. Helena Barba-Meinecke

INAH Quintana Roo
Arq. Carmen Rojas Sandoval

UCSD Cultural Heritage Engineering Initiative
Dr. Falco Kuester
Dr. Dominique Rissolo
Eric Lo
Vid Petrovic

Earth Analytic Inc
Dr. Wetherbee Dorshow

McMaster University
Dr. Eduard Reinhardt

UNAM
Dr. Fernando Álvarez

CONANP
Biol. Angel Omar Ortiz Moreno
Biol. Oscar Guzmán
MEP Eduardo Chaires Montecinos

Woodville Karst Plain Project (WKPP)
Global Underwater Explorers (GUE)
Phreatic Sardinia
Bahama Caves Research Foundation
Antonio Laviada & Antonio Laviada Jr.
Alex Monforte
Don Otilio Ruiz Cruz, Doña Catalina Manuela Ortega y Adolfo Ruiz
Don Armando Romo
Fundación Selva Maya AC

2022 Exploration/Resurvey Team:

Alejandro Alvarez, Jim Babor, Angie Brown, Paul Brown, Sigurd Bowitz, Ricardo Constantino, Fred Devos, Stefan Dreesbach, David Dusek, Kirill Egorov, Bruno Espinosa, Julien Fortin, Mark Garland, Osama Gobara, Shannon Hannan, Jose Luis Hernandez, Jeremias Hernandez, Alexandre Jardim, Brian Kakuk, Kyungsoo (Jerry) Kim, Su Eun Kim, Gideon Liew, Robert Lourie, Chris Le Maillot, Sam Meacham, Alberto Nava, Annika Persson, Ed Reinhardt, Andreas Rosland, Jan Schmidt, Sabine Sidi-Ali, Flip Vernooij, David Watson, Michael Westreicher

MCEP / CINDAQ December 2022 Science Project Participants

Blaine Ashworth, Sigurd Bowitz, Laurent Dahan, Fred Devos, Julien Fortin, Gustavo Fragoso, Peter Gartner, Richard Goldberg, Herwig Hoffmann, Kyungsoo (Jerry) Kim, Su Eun Kim, Frank Madden, Josh Maxwell, Chris Le Maillot, Sam Meacham, Viktoria Mitina, Roman Mykhailov, Ed Reinhardt, Manuela Schoch, Sebastian Von Koss, Alex Vronskiy, Joana Weil

Photo Credits

JP Bresser, Fred Devos, Kirill Egorov, Julien Fortin, Chris Le Maillot, Sam Meacham, Alberto Nava

CINDAQ
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 2022 Report

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

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