Cave Diving Exploration

Izvor Licanke, Fužine, Croatia

2022 Report

18th June 2022 – 4th July 2022

Cave Diving Group of Great Britain

Global Underwater Explorers

Figure 1 Christine and Mitchell in chamber 1. Image: Mark Burkey

Detailing the 2022 cave exploration and documentation of Izvor Licanke.
2022 publication.

Report: Christine Grosart, 2022.
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Figure 2 Carrying equipment. Image: Mark Burkey.

Abstract
The objective of the expedition is to explore virgin cave passages both underwater and above, using advanced cave diving and caving techniques.
The cave is called Izvor Licanke and it is in Fužine, Croatia, near Rijeka.
In its seventh year, the team is organized by expedition leader and exploration diver, Christine Grosart.
The cave had not been explored since 1999 and after a reconnaissance, a team was built to pick up where previous explorers had left.
Exploration divers were involved along with their underground support team, all of whom were required to cave dive to enter the cave system.

2022 Summary
This expedition stepped up a notch owing to the remoteness and multi-sump nature that that cave was now taking.
A team of 8 divers, including 4 ‘push’ divers capable of passing the deep barrier of sump 2, explored new cave comprising 5 separate days underground. This included 2 gear carrying days, two exploration days and a final survey day.
On the first exploration day, Christine Grosart and Osama Gobara explored and mapped the un-dived sump 5. On the second exploration day, Osama Gobara and Mauro Bordignon passed sump 5 to discover sumps 6, 7 and 8 which were interspersed with short sections of sandy airbells. They continued after sump 8 in a large, high canyon of significant dimensions which then broke into a huge dry chamber with enormous boulder break down. At the end of this, the cave starting to turn, now heading southeast, they discovered another, until now un-dived sump.
On the final extended day beyond sump 2, Osama Gobara and Mauro Bordignon surveyed the passages they had found in some detail and took video and photographs as they went. They did not dive sump 9 at the end of the huge chamber but did film it and it looked to be promising.
The total length of new cave discovered in 2022 is 938m, bringing the total cave length to 2819m.

Introduction
History of exploration of Izvor Licanke.

1992
The first sump was first dived by Tihomir KOVACEVIC, Zeljko PSENICA and Boris WATZ (D.I.S.K.F. Zagreb) for 40metres distance and maximum depth 6 metres.

1998
Frank Vasseur (FR), with the support of local cavers and divers, explored the second sump to a depth of 36 metres, at 140m distance underwater.

Project Background

May 2015
Krnica Dive Centre, well known to Richard Walker (GB) and Christine Grosart (GB), was able to obtain government permits to access cave diving sites across Croatia.
Many divers passing through the popular wreck diving centre were also cave diving trained and so a reconnaissance cave diving week was put together under the project name ‘Project Morpheus’.

Christine Grosart joined the trip and among other sites, was able to dive a site called Izvor

Licanke.
Very little was known about the site, but it had a man-made entrance which facilitated a pumping/potable water filtration station for the local town of Fužine.
Christine made a dive through the first sump with dive partner Anton Van Rosmalen (NL) and found it to be only 5 metres deep and about 40 metres long.
They surfaced in a large cave passage with underground lakes to be passed. The divers were inappropriately kitted out for caving in dry suits and twinsets, so they retreated to try and find out more about the cave system.

On surfacing the divers were met by the local workers at the pumping station who produced an old Corel Draw survey of the cave, which detailed a second sump after some 400 metres of 'dry' caving. Coupled with the dive line in sump 1 which had orange tags, a telltale sign of a French cave diver called Frank Vasseur, Christine located an online report of his exploration in the cave in 1998 and 1999.

Frank explained that government permissions had been lost and nobody had dived the cave since. Owing to customary politeness, Christine asked Frank if he would mind if she continued exploring the cave, as he had not been there for about 20 years. Frank was very happy for her to do this and explained as best his memory would allow how the underwater line ended 'wide open'.

The expectation was that there was a significant opportunity to map completely uncharted territory, film it and as a by-product, highlight an expedition run by a woman who was also a lead explorer.

July 2015
Christine returned later in the summer with her partner Richard Walker to attempt exploration of the second sump using lightweight side mount techniques. They ran into difficulty as the second sump seemed elusive and they kept running into dead ends in high-level passages.
It was also deemed that a lightweight approach without support was not appropriate in this cave and help was sought.

June 2016
Christine and Richard returned with support from Rick Van Dijk (NL) and were able to locate sump 2. Using side mount techniques to facilitate an easier 'carry' to the sump and a decompression gas cylinder each, the divers located the end of Frank Vasseur's exploration line 136 metres distance into sump 2 at 36 metres depth.
Christine dived ahead and laid a further 42 metres of line in distance which coincidentally went to 42 metres depth before their gas reserves forced them to turn the dive.

June 2017
Christine and Richard returned with reinforcements. Rick Van Dijk supported in between sumps, along with Ash Hiscock (GB) and Mark Burkey (GB), a renowned cave photographer.
Using multiple cylinders (6 each) Christine and Richard extended the line a further 99 metres with the maximum depth reaching 50 metres.
The aim was to produce a film about the exploration and document the project in both images and video.

June 2018
The same team returned with the addition of Roberto Varesko (HRK) helping to carry the equipment underground. Ash was invited to join the 'sharp end' of exploration and Christine, Richard and Ash all used rebreathers rather than open circuit which increased the logistical efficiency.

Between them over three dives they extended the underwater passage in sump 2 by another 247 metres, with much of the cave passage remaining at an average depth of 45 metres.
Christine produced a short film about the project that was shown at the 2018 Kendal Mountain Festival.
Mark Burkey shot high quality images and video of the project and several articles were published in Descent, Diver and Dutch Speleo magazines.
Christine gave several talks on the project at the Dive Show (UK), Hidden Earth National Caving Conference (UK), Cave and Wreck night (NL), Global Underwater Explorers Conference (USA), Severnside Sub Aqua Club.

June 2019
In its fifth year, the team was again organized by expedition leader and exploration diver, Christine Grosart.
Three exploration divers were involved along with their underground support team, all of which were required to cave dive to enter the cave system.
The expedition went to plan with three exploratory dives conducted and 601 metres of new cave passages, both underwater and above, discovered.
This brought the total length of the cave in 2019 to 1623metres, of which 1,125 metres had been discovered by this team.

The exploration was successful with no incidents and a survey of the new cave was conducted with numerical results as well as video imagery of the new discoveries.
The new discoveries yielded two new sumps (3 and 4) and to the team's excitement, the end of the deep sump 2.

June 2020
Cancelled due to Covid-19 global pandemic.

June 2021
Cancelled due to Covid-19 global pandemic.

August 2021
The expedition encountered a significant blow when one of the push divers became unwell (tested negative three times for covid) and was unable to dive. A standby diver was requested at very short notice to come in from his own expedition in France to accompany Christine Grosart in exploring sump 4 and beyond.

Thus, one familiarization dive through sump 3 was conducted by Miss Grosart on a solo dive and one exploratory dive was undertaken by Miss Grosart and Mr. Anton Van Rosmalen from the Netherlands.
Just over 100 metres of new cave passages, both underwater and above, were discovered in addition to a further sump 5.
This brought the total length of the cave to 1623 metres, of which 1,229 metres has been discovered by Miss Grosart's team over 6 years.
The exploration was successful and a survey of the passage between sump 2 and 3 was conducted to BCA grade 4/5 as well as supporting images.
The new discoveries yielded the completion of sump 4, new dry passage beyond and a new sump 5.
The support divers conducted a centre line survey of the dry cave between sumps 1 and 2 as the original data from 1998 was not available. Christine Grosart also re-lined sump 1 and re-surveyed it, while Miss Louise McMahon removed the 20-year-old original dive line. The resurveyed centre line amounted to 678.54 metres from the entrance to sump 2.

June 2022
In its seventh year, the expedition stepped up a notch owing to the remoteness and multi-sump nature that that cave was now taking.
A team of 8 divers, including 4 ‘push’ divers capable of passing the deep barrier of sump 2, explored new cave comprising 5 separate days underground. This included 2 gear carrying days, two exploration days and a final survey day.
On the first exploration day, Christine Grosart and Osama Gobara explored and mapped the un-dived sump 5. On the second exploration day, Osama Gobara and Mauro Bordignon passed sump 5 to discover sumps 6, 7 and 8 which were interspersed with short sections of sandy airbells. They continued after sump 8 in a large, high canyon of significant dimensions which then broke into a huge dry chamber with enormous boulder break down. At the end of this, the cave starting to turn, now heading southeast, they discovered another, until now un-dived sump.
On the final extended day beyond sump 2, Osama Gobara and Mauro Bordignon surveyed the passages they had found in some detail and took video and photographs as they went. They did not dive sump 9 at the end of the huge chamber but did film it and it looked to be promising.
The total length of new cave discovered in 2022 is 938m.
The total new cave explored by Christine’s team since 2015 is 2167m.
The total cave length to 2819m.

The figures were adjusted slightly after a re-survey of sump 4 and the survey of the cave including side passages was completed this year.

Information on the survey:

- Survey contains 1180 survey stations, joined by 1180 shots.
- There is 1 loop.
- Total length of survey shots = 2819.49m (2819.49m adjusted)
- Total plan length of survey shots = 2695.68m
- Total vertical length of survey shots = 531.54m
- Vertical range = 79.13m (from 1103 at 746.33m to 600 at 667.20m)
- North-South range = 1545.73m (from 1134 at 15088078.08m to 28 at 15086532.35m)
- East-West range = 387.07m (from 489 at 1416918.71m to 935 at 1416531.64m)

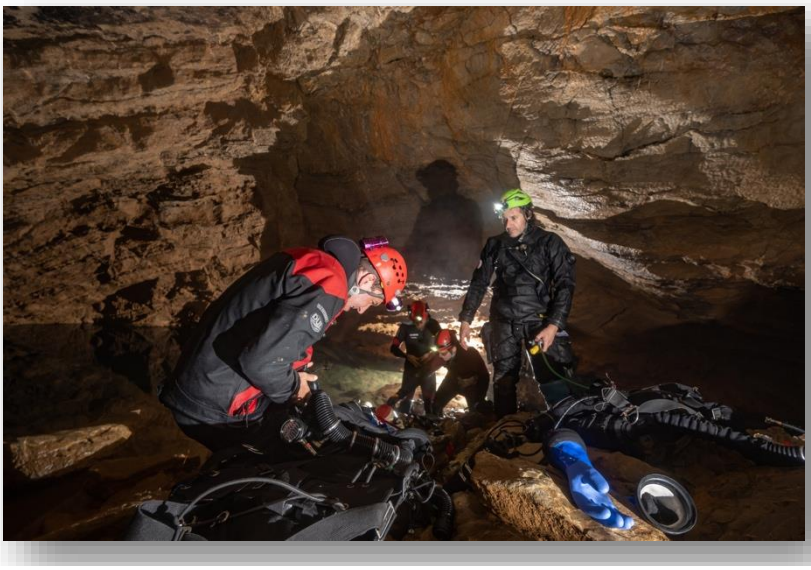


Figure 3 Osama and Mauro preparing equipment at sump 2. Image: Mark Burkey.

Location and Maps
Izvor Licanke resurgence.
Latitude: 45° 19.720'N Longitude: 14° 42.094'E
Country: Croatia. Town: Fužine

Figure 4 Map source: Google Earth Pro™

Figure 5 Map source: Google Earth Pro™

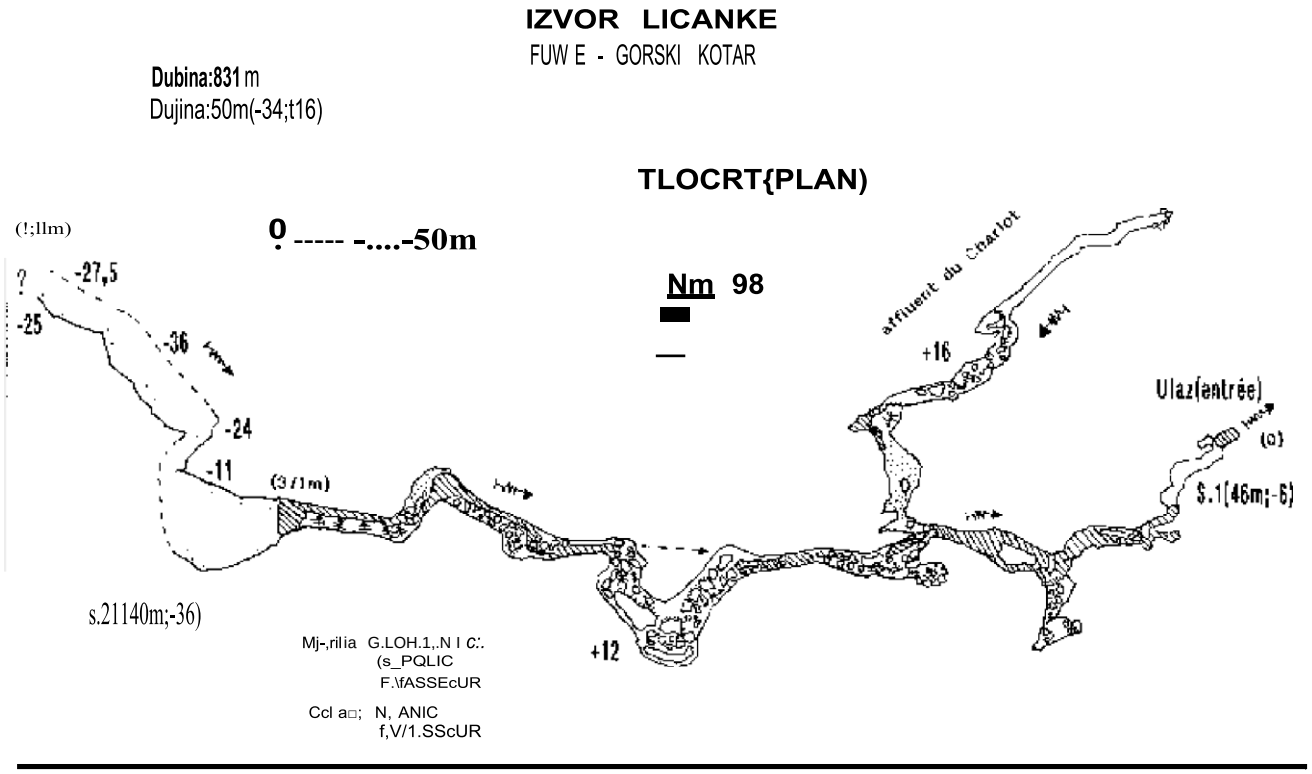


Figure 6 1998 Survey of Izvor Licanke, sump 1 leading to sump 2. Source: Plongeesout.com

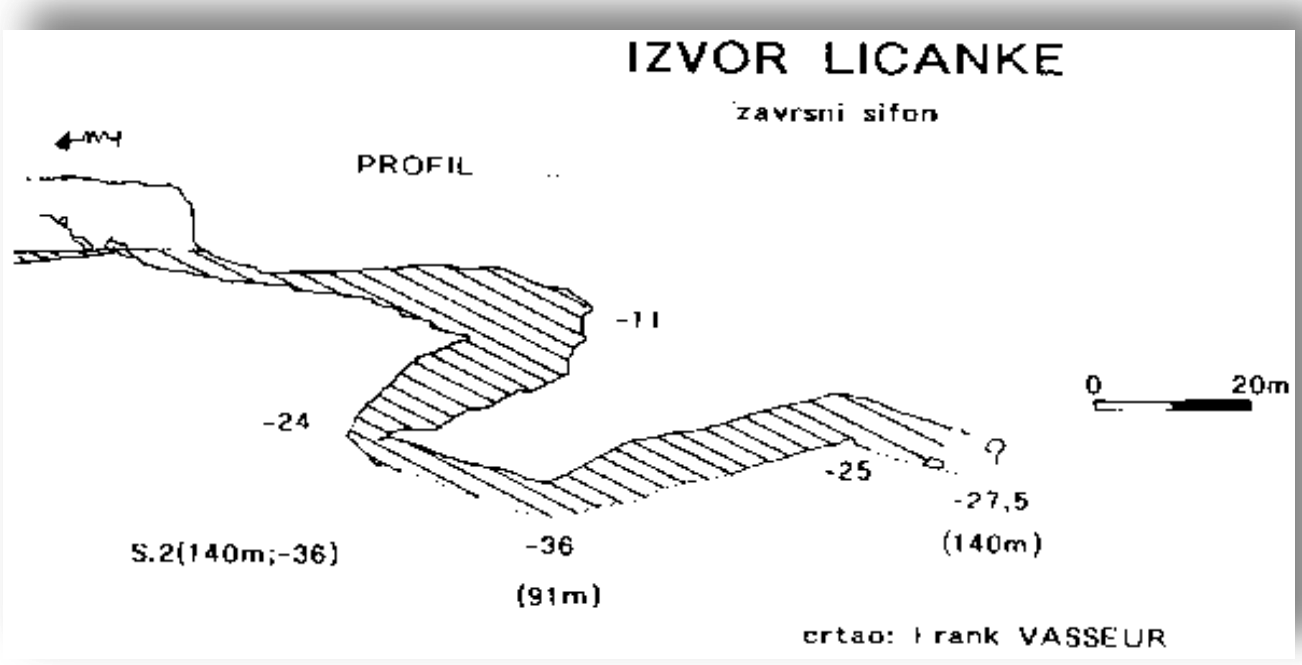


Figure 7 1998 Survey of Izvor Licanke, sump 2. Source: Frank Vasseur; Plongeesout.com

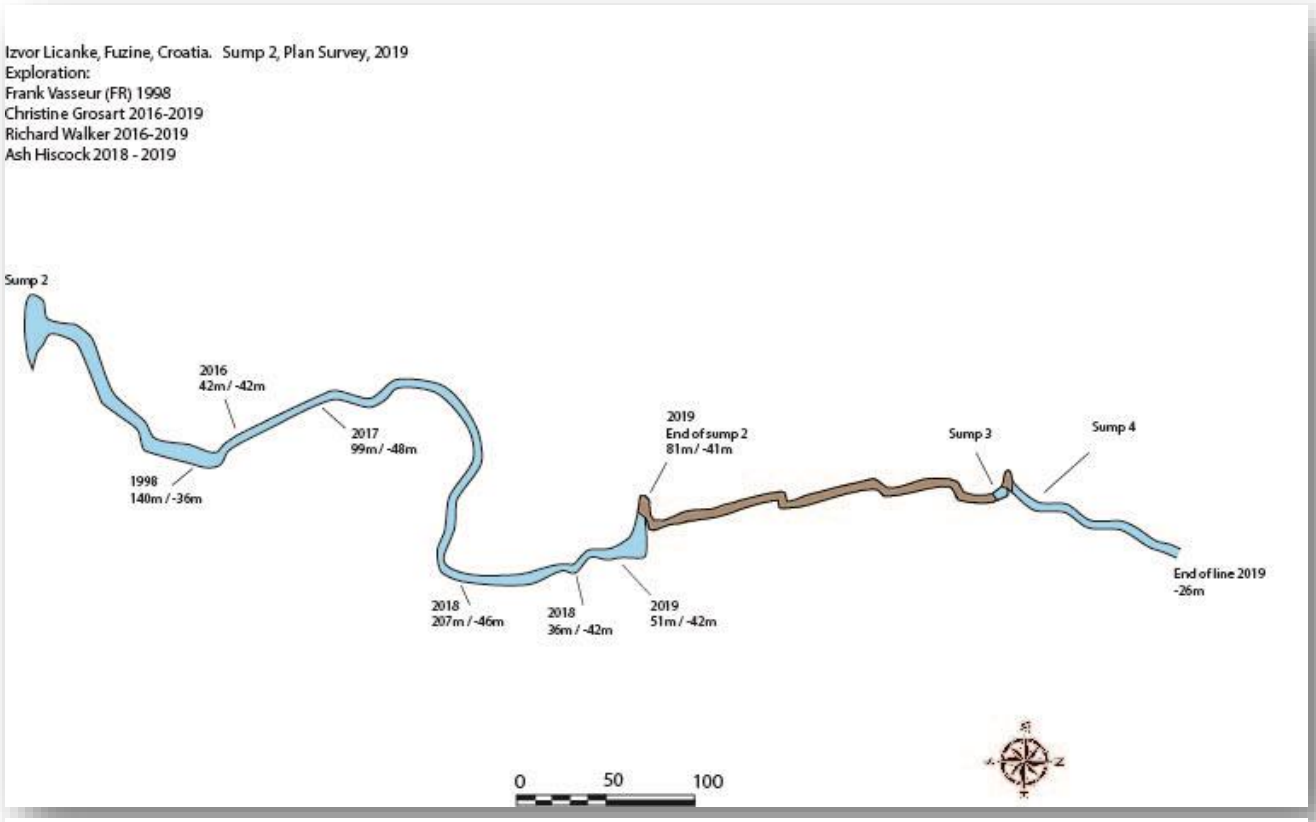


Figure 8 Survey of Izvor Licanke 2019 terminus. Source: Christine Grosart (GB)

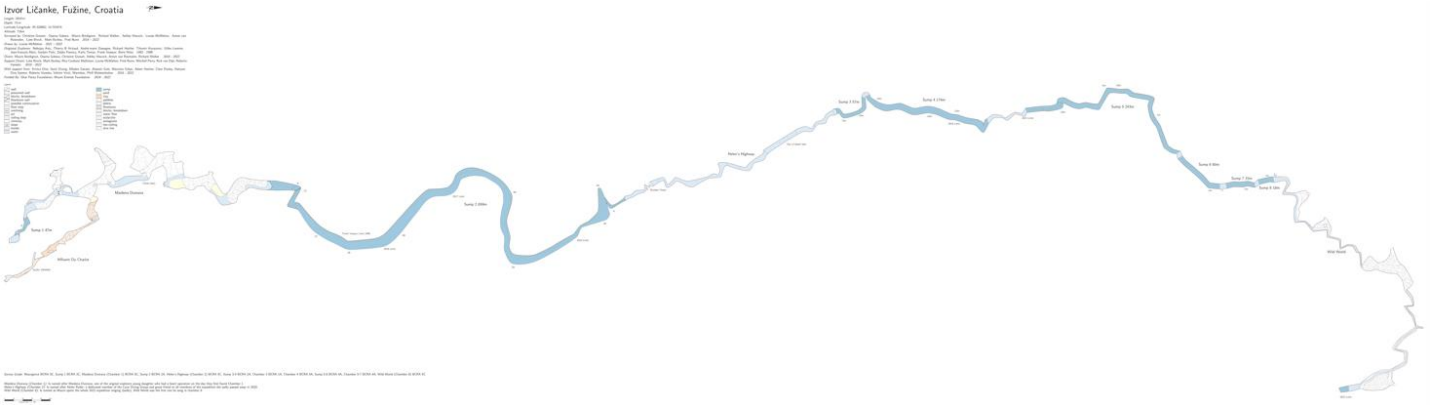


Figure 9 Complete survey of Izvor Licanke to 2022 terminus. Drawing: Louise McMahon (GB)

Expedition members 2022

Christine Grosart
(UK)
Expedition leader/Exploration Diver/Survey
FdSc Paramedic / Offshore Dive Medic
Caving Instructor
Record Breaking Cave Diver
Cave Diving Group (GB) Examiner
Global Underwater Explorers Tech 1/Cave 1
IANTD Full Cave
KISS CCR
23 years caving experience
18 years cave diving experience
13 years in cave diving exploration, with the end of the line in 3 caves in France and one in Croatia.
Fellow Royal Geographical Society
BBC Women's Hour Power List 2021
Award winning film maker.

Richard Walker PhD
(UK)
Support Diver
Professional diving instructor (CCR/Technical/DPV) Global Underwater Explorers
Instructor Evaluator – Global Underwater Explorers
PhD medical physics
Cave 2 qualified - Global Underwater Explorers
Cave Diving Group (GB) examiner.
4000 + dives
Project cave diver on Karst Odyssey (Bosnia), WKPP support diver (USA), cave diving exploration in France, team diver on the MARS project, Sweden.
Fellow Royal Geographical Society

Mark Burkey
(UK)
Support/Video/Images
Rope access Level 3
Caving for 12 years
Cave Diving Group diver
Award winning cave photographer
Documenting and photographing caves worldwide
Member of 3D scanning project for world's largest chambers
Photographer for National Geographic
Caving expeditions in Slovenia, Northern India, Mulu, China, Belize and Thailand.

Louise McMahon
(UK)
Support / Survey
Caving for 4 years
Cave Diving Group member
Caving clubs: Technical Speleological Group, Northern Pennine Club.
Dry caving exploration in the UK. Licanke is first expedition

Osama Gobara
(Austria)
Hydrographic Surveyor
Caving for 20 years
Cave diving for 15 years
Full cave instructor and CCR diver for Global Underwater Explorers.
Mexico Cave Exploration project diver; Purification Exploration Project (Mexico); Several cave explorations in France, Mexico, Bosnia and China; Syst ema Purification Project member and Mexico Cave Survey, founding member

Mauro Bordignon
(Italy)
Cave Diving Instructor (TDI)
Caving and cave diving for 23 years
100+ km of underwater cave explored in Mexico; Cave diving exploration in Madagascar, Northern Italy and Sardinia.
Photography and media projects in Mexico and Madagascar.

Luke Brock
(UK)
Radiographer
Caving for 5 years.
Cave Diving for 2 years, current member of cave diving group and GUE diver.
Successful cave diving exploration in Derbyshire, UK.
Active in pursuing new cave in the UK.
Member of Technical Speleological Group.

Mitchell Parry
(UK)
Operations Manager.
Caving and cave diving for 4 years.
Diving for 8 years; Full cave certified, Tec 50, Divemaster.
Member of Wessex and Craven caving clubs and the Cave Diving Group.

Velimir Vrzic
(Croatia)
Local Logistics and permits

Fieldwork Background

This project began in 2015 during a project to explore several cave resurgences in the regions of Otocac and Rijeka. Licanke had not been further explored since 1998 and was the focus of our attention.
The expedition organiser had experience and expertise in multi-sump cave diving exploration and the project was ideal for her skill set and that of her team.
Licanke was reported to be ‘ongoing’ with the underwater passage in sump 2 still ‘wide open’ so a project was set up to go and continue extending this cave.
The resurgence exit area is heavily man made and has pumping filters used to filtrate water for both drinking and hydropower for the local town of Fužine.

Our exploration and associated survey are of great interest to the local water company as they have no data at all, of where the water is coming from or the quality of it upstream. At the beginning of this expedition, the team had discovered 1125 metres of new cave, all

underwater. The limit of exploration now lay 1623 metres from the entrance, including 4 sumps and 3 dry chambers in between them.

Planning

Primarily the planning was done by expedition organiser Christine Grosart who delegated travel arrangements to Louise. Mark Burkey was put in charge of ‘base camp’ at sump 2 as well as photography and videography.
Local logistics manager Velimir Vrzic kept in contact with the water board at Fužine for regular updates on weather conditions and water levels at the cave.
As the usual dive centre was not available, all divers needed to fill their cylinders in the UK and transport them in the vehicles heading down to Croatia.

Lessons Learned

Based on feedback from 2021, the organisers used Trello, an online project managing programme, to organize everything from travel, equipment and shopping lists to the schedule.
This had mixed results. It was very useful to the people who used it.
The most valuable list was ‘Issues to fix from 2021’ which we managed to cover in its entirety. We rectified all issues identified from the 2021 wash up meeting and this led to a very smooth expedition with very little going wrong with either people or equipment.

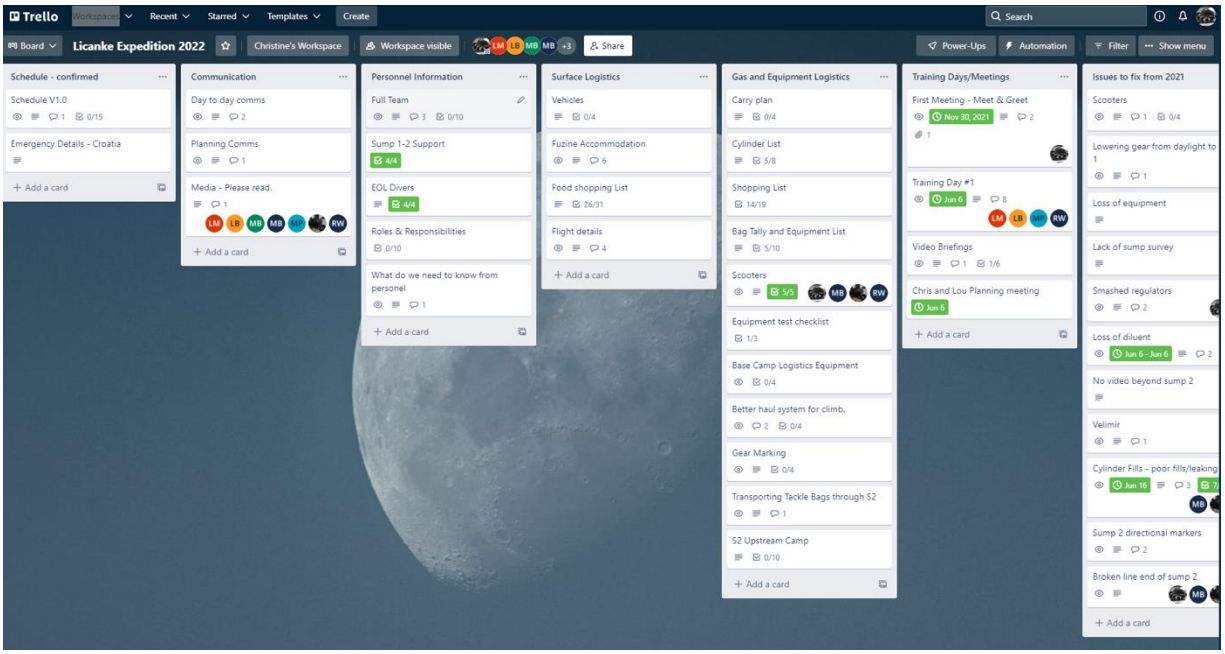


Figure 10 Trello application, used for expedition team planning.

Aims

The aim of this year’s project was to continue exploring the ongoing cave system by diving the virgin sump 5 and beyond and to survey the new cave passages from 2021 in sump 4 and the dry passage beyond. In addition, as with every expedition here the intention was to document the mission using underwater video and cave photography. This year we attempted some water, sediment and rock samples to analyse for the presence of microplastics and petrographic analysis.

Figure 11 Louise and Fred survey to grade 5 in between sumps 1 and 2, Izvor Licanke 2021.

Methods - Survey

Underwater surveying techniques vary slightly from standard cave survey techniques. It is desirable to record survey data when new cave is discovered, ideally for a BCRA (British Cave Research Association) grade 3 survey. This is the highest-grade survey that can be reasonably expected underwater. It comprises:
Grade 3: A rough magnetic centerline. Horizontal and vertical angles measured to ± 2.5°; distances measured to ± 50cm; station position error less than 50cm after closing loops. Compass calibration taken from local magnetic variation.
In practice, underwater cave surveys are somewhere between a grade 2 and grade 3 survey.
A clinometer is not used, but instead a depth gauge used to measure the topography. For direction, Christine used a Silva™ walking compass early in the week. In 2019 Ashley used a digital compass, which formed part of his Shearwater™ diving computer.
For distance, the new dive line is knotted every 3 metres and divers count the knots underwater between survey stations and translate into metres for the survey.
A rough visual estimate of passage size (Left, Right, Up, Down) is made at each station. The accuracy or ability to record passage dimensions depends on the visibility. The camera footage post-dive is also useful here.

Passage drawing on exploration dives typically is only ‘a’ level, where only the centerline is drawn.
We attempt to gauge some passage dimension where possible so it would be fair to say our survey meets somewhere between grades ‘b’ and ‘c’ where attempts are made to measure passage at most stations and separate walls are drawn in that approximate the passage size. The dry cave passage between sumps 1 and 2 had been surveyed by the original team in the 1990s but this raw data was not available and in previous years we had reverse extracted it from the original survey.
In 2021 the team kept themselves busy surveying a centre line between sumps 1 and 2 so

that we had a full data set from daylight to the end of the cave system.
This was completed to grade 5 using SAP5, Android phone and Therion cave survey software.

Innovative Technology

Paralenz Vaquita Dive Camera
We were very fortunate to have the use of a Paralenz Vaquita dive camera, which came into being around 2020. Rated to 350m depth, the camera is robust and compact. It has a slightly wide-angle lens and is capable of 4K video.
The camera tracks the dive profile, so it is uniquely possible to pick any point on the dive and view the video from that exact point. This is particularly useful for reviewing the dive and filling in cave passage details on the survey as the whole dive is recorded including depth, time, profile and temperature.
The new vaquita had a rear live view screen, making framing a shot much easier and precise than its predecessor. The disadvantage is a vastly reduced battery life.
An original Paralenz was used as a backup and to film in the dry passages.

She-P
Women have always run into difficulties when doing long, cold and deep dives in dry suits. It is imperative that divers are well hydrated, and this becomes even more critical when decompression is involved.
Very few women delve into technical diving and one of the reasons is the inability to pass water during the dive. Their male counterparts have had this solved for many decades with the use of sheaths and pee valves installed in dry suits but owing to the female anatomy, a viable solution did not appear until 2006 when it was invented by Dutch female cave diver, Heleen Graauw.
This innovation has been a game changer for all female technical and cave divers and removes the only other option which was ugly, uncomfortable and eco-hostile adult diapers. Christine has used the She-P silicone device for the last 3 expeditions, and it even survives the caving trip to and from sump 2. It is not too much to say that this expedition may have been cut short some time ago for a woman, without this innovative device.

Mnemo Digital Survey device.
The Mnemo is a fully integrated underwater survey device, which measures distance, azimuth and depth. This enables the diver to attain a much higher accuracy of data and to survey whilst swimming along, which is much more efficient. In turn this enables the diver to concentrate more on the dive than on survey notes.
Files are automatically saved to the device and data is easy to download and is compatible with cave survey software.
A noted big advantage is that the device records two azimuths which means it self corrects any errors.

Field Data

Survey data is recorded on Wetnotes (underwater writing pads) and filmed on the Paralenz Dive Camera.
All survey data was entered into Therion cave mapping software and drawn within this programme. Grade 5 survey was achieved using SAP5 and android phone between sumps 1 and 2. For survey in dry passage between sumps 2 and 3, the divers used a Disto X and Samsung galaxy phone with Topodroid software.
All software was set up to convert to Therion files.

Results
The results of the exploration dive concluded the following:

Exploration Divers: Christine Grosart, Osama Gobara, Mauro Bordignon.
Total new cave explored in 2022: 938m
Total Cave Length: 2891 metres (centre line) at 2021 end
Total Cave explored by UK team since 2015: 2167 metres.
Water temperature: 7 degrees in all sumps.
Visibility in sump 2: 10 metres
Visibility in sumps beyond sump 2: 15 metres

Figure 12 The Licanke 2022 underground team. Back row left to right: Christine Grosart, Louise McMahon, Richard Walker, Luke Brock. Front row left to right: Mark Burkey, Osama Gobara, Mitchell Parry, Mauro Bordignon.

Surface weather

The expedition was treated to glorious weather on the surface, in the high twenties most days and over 30 degrees on some. This made the rest days very pleasant and washing and drying equipment much easier. It also meant that the cave water was in good condition and visibility average for this cave system.

Project Modifications

Personnel

Several factors meant that we were short on a few key people this year, but this did not adversely affect the expedition hugely.
One invited individual had failed to attend two of the online meetings for the expedition and had also pulled out last minute for a dive training day. At this stage the expedition leader Christine Grosart made the decision to remove him from the expedition due to lack of engagement.
A key role had been identified as ‘camp boss’ and we required someone to keep house, cook at all times of day and night to ensure the team were fed on entering and leaving the cave.
Unfortunately one of these volunteers, Elaine, had fallen at home and badly damaged tendons in her wrist which had been further compounded by errors in her surgery. This rendered her unable to use her dominant hand at all, this she had to pull out of the trip. This meant the team needed to cook, clean and keep house by themselves. This was mostly managed well thanks to some good cooks and conscientious people**.**

Access

On arrival, a large fence had been erected around the cave resurgence. We were afforded a key for access but due to workmen in the vicinity, the team had to adjust the usual relaxed style of moving equipment to an organized chain from the cars to the cave. This actually benefitted us as it was more efficient.

Discussions and conclusions

The discoveries made in 2022 at Izvor Licanke surprised the team. Nobody expected to find a dry cave chamber of the magnitude of ‘Wild World’ although possible further, shallow sumps were expected.
This is now one of the most significant cave discoveries in recent years in Europe. The many months of planning paid off and three excursions without incident were made to the end of the cave as planned. The cave was surveyed in its entirety both above and underwater, with the remainder of chamber one resurveyed to complete the entire system in Therion.
A special mention of thanks must go to Louise McMahon for her diligent approach to drawing up the survey and completing the map of the system for completeness.
For the first time, the team had the capacity to take water and rock samples for analysis from various parts of the system.
As the cave has started to trend southeast rather than its usual norther trajectory, it is now casting doubt as to whether the water source is the nearby, northern Lokve lake.
In addition to the carry and set up day, it is taking two divers no less than 17 hours entrance to entrance to reach sump 9. This is without stopping for breaks but includes surveying time. The divers are surfacing very late at night which causes some logistical issues.
Consideration now has to be given as to whether camping beyond sump 8 is feasible. There are no suitable camping spots (due to water) until after sump 8 and carrying camping gear as well as diving gear to this part of the cave is significantly more time consuming and requires more set up dives and more divers capable of getting there.
At this stage we are not sure this is the route we want to go down, so the team will be taking some time out for discussion and either way, training up some more divers to pass sump 2.

Administration and logistics

Destination Area

Fužine is notable for the sparsity of information available both on the internet and in the local tourist information office!
All sources give a variation of the following:
Fužine originated in the 17th century, when the Zrinski family began digging iron ore and the name of the site originated. 'Fužinarstvo' is the word used for mining and iron ore processing.
Fužine's tourists have been visiting since the end of the 19th century, more precisely since 1874, when the first organized group of guests from the Croatian Littoral in the area was recorded. More 100 years before that, there was a stopping place along the Karolina Road, where first travellers and tourists visited.

Fužine is located 730 metres above sea level, in the southwestern part of Gorski Kotar, surrounded by picturesque mountains, with centuries-old pine forests and beautiful lakes. To this day, Fužine benefits from the development of very good road links, close to the motorways.
Fužine is known for its clean mountain air. From the surrounding peaks (Bitoraj 1385 meters, Visevica 1428 m, Tuhobic 1106 m, Preradovic 885 m) there are beautiful views of the wooded areas of Gorski Kotar and the nearby lakes, villages Vrata, Lič and Fužine, karstic Licko polje, sea, coast and Kvarner islands.

Today there are three reservoir lakes: Bajer, Lepenica, and Potkos.
The Licanke riverbed is 20.4 km long. It runs under Rogozna and Petehovac in Gorski Kotar and runs through the upper part of Fužine and rises on Ličko polje near Liča.
Under the name of Dubračina, it rises again in Vinodol near Mali Dola and in Crikvenica it joins the Adriatic Sea.

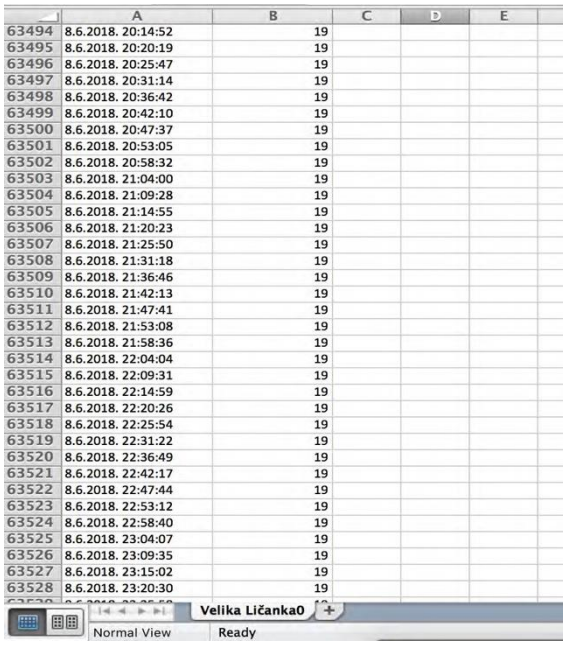
Along with the construction of a dam, in 1952 the artificial lake Bajer was formed in Fužine. This makes Fužine a significant tourist and fishing destination in the Primorje-Gorski Kotar County.

Research

We were delighted to welcome Prof. Ph.D.Sc. B.Sc.Eng of Geology Mladen Garasic to meet us while we were in Fuzine.
Mladen's CV is extremely impressive and he has unrivalled knowledge of the karst of Croatia.
He is both a hydrogeologist and speleologist and enjoyed cave diving in Croatia in his youth. He has published over 327 scientific papers and articles in subjects relating to hydrology, geology, mining, geotechnics and karstology.
He has had a keen interest in this project from the outset and was very excited to learn that a team had returned after 20 years and was making discoveries.
We offered Dr Garasic the opportunity to receive some rock (5cm x 5cm x 5cm) for petrographic analysis. This rock sample was taken from part way up the side wall in the large chamber close to the end of the known cave. Analysis is still in progress.
The divers also took sediment and water samples from the upstream end of sump 5 the far reaches of the Izvor Licanke system (undived sump 9) for analysis at Chester university for the presence of microplastics.

The website 'Plongeesout' is particularly useful as it documents the exploration of Izvor

Licanke in the 1990s. Frank Vasseur, the original exploration diver of sump 2, was extremely useful and helpful as far as his memory would allow.
Technology such as Google Earth Pro are extremely useful for getting a handle on the geography of the area and for overlaying our cave survey.
The local water board of Fužine monitor water levels and temperatures all year-round multiple times a day and they were very happy to make this data available to us so that we could spot trends in the water levels according to rainfall and try to ascertain the size of the catchment for this underground river system.



	A	B	C	D	E
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63527	8.6.2018. 23:15:02	19			
63528	8.6.2018. 23:20:30	19			

Velika Ličanka0

Normal View Ready

Figure 13 Water levels data from 2018 expedition.

Data source: Water board of Fužine.
Date / Time of reading / Water level height at measuring station (Just downstream of the resurgence of Licanke) in cm.

Training and Equipment Testing
Closed Circuit Rebreathers

Exploring sump 2 was originally done on open circuit scuba, using cave diving techniques and gas rules.
Logistics are the primary reason for using rebreathers. Carrying multiple cylinders of open circuit gasses, that can only be used once per dive, is neither economical nor efficient. Rebreathers allow gas to be recirculated and open circuit ‘bailout’ bottles are carried with the diver and staged at key intervals along the dive line, or ‘staged’ to allow an open circuit retreat in the event of rebreather malfunction or failure.

There are many different rebreathers on the market, but for this type of cave expedition, the least complicated the better. In the event of complex electronics going wrong, the rebreather can no longer be dived, and resolution usually involves a return to the manufacturer.

Thus, the choice of rebreather depends on the following factors:

Scrubber time (the amount of CO2 the sofnolime scrubber can handle safely)
Work of breathing in a cave profile
Amount of electronics - to be reduced as much as possible
Fixability in the field
Size and weight for carrying through dry cave
Fragility

Depth and temperature capability

Christine Grosart uses the KISS Classic, which is a fully manually operated rebreather with a KISS valve which trickles oxygen into the system at the metabolic rate of the diver. Additional oxygen is then added manually.
These units are small, light but within excess of a 4-hour scrubber time, work well in cold water and are relatively easy to repair in the field.

Richard Walker uses a JJ closed circuit rebreather, which has an automatic oxygen injector called a solenoid. This reduces the need for the diver to inject oxygen manually to maintain the partial pressure of oxygen at the optimum setting at any point.
However, this unit is much bigger and heavier than the KISS and less suitable for carrying through dry cave. It has more potential for failures that are harder to fix in the expedition field.

Osama and Mauro were using a lightweight sidemount rebreather called a KISS sidewinder. This is a fully manual CCR which is smaller and lighter than Christine's backmounted KISS CCR. It enables sidemount configuration which is beneficial for smaller cave passages and remote access.

Scooters (Diver Propulsion Vehicles)

Owing to the cold water temperature and ever-increasing threat of even more decompression the longer this cave got, it made sense to introduce scooters to the project. Scooters are battery-powered torpedo-like tubes with propellers that tow the diver through the water at a much greater speed than they could swim.
This reduces the amount of time that the divers would spend at depth and thus, decrease the amount of decompression obligations they would build up.

Figure 14 Christine Grosart with Suex scooters. Image: Mark Burkey

Any way of reducing the decompression obligation in 7 degrees of water was very welcome.
They came with a downside and that is transporting them through the dry cave between sumps 1 and 2.
Scooters are extremely expensive (circa £6k new, each) and the handles and propellers are easily damaged.
We judged that we needed 3, so that each diver would have access to a spare on any dive. One diver had a primary scooter and tow another back up scooter behind them.

This meant that the bailout gas logistics could stay the same as the year before, even though the cave would undoubtedly get longer.
The limitations on this plan were the loss of ability to scooter owing to visibility.
The visibility was not excellent – only about 6 metres and milky – so it was possible to scooter, but the divers needed to take care to preserve the visibility.
We are very grateful of the assistance from Suex Scooters who made the purchase more manageable.

Logistics

Permissions and Access

Permission for this cave access is required from the government of Croatia. This was arranged for the team by local contacts. Permits and identification were available always should the authorities need to inspect them.
Velimir Vrzic was on site, always as a condition of the permit is that a Croatian speaking official should be at the site during all excursions into the cave.
Evidence of permission is available to the Mount Everest Foundation.

Fundraising and Financing

Expedition organiser Christine Grosart applied for a grant through the Ghar Parau Foundation, and this connected with the Mount Everest Foundation.
Ghar Parau granted an award of £600.00
Mount Everest Foundation granted an award of £3500.00
The remainder of the expedition was self-funded by the individuals on the team.

Summary of costs:

	Travel	Accommodation	Food	Logistics
Christine	£900	£295.50	£150	Rental Car £160
Richard	£800	£295.50	£150	Permits, Local Logistics £750
Ferry	£200 pp			Diving Gas £500
Fuel	£600 pp			Cylinder Bags £410
Tolls	£100 CG			Boltsnaps £160
Mark Burkey	£240	£295.50	£150	Sofnalime £140
Louise McMahon	£240	£295.50	£150	Daren Drums £120
Mauro Bordignon	£50	£295.50	£150	Rocket Tubes £30
Osama Gobara	£50	£295.50	£150	Planning stationary £200
Luke Brock	£200	£295.50	£150	
Mitchell Parry	£240	£295.50	£150	
Total	£2720	£2364	£1200	£2470

Figure 15 Table of expedition costs

Total cost of expedition: £8,754
Total Funding: £4,100

Ghar Parau funding was paid via BACS directly into the organiser's account. A separate savings account was set up for the funding. Mount Everest Foundation sent a cheque, which was paid into the same account.
A cash withdrawal was made and the landlady of the accommodation in Fužine was paid in full in local currency, Kuna.
£100 was distributed per head towards travel costs. The remainder of funding covered the accommodation costs, rental car and diving gas, as these were all used equally by the team.

Insurance

Individuals on the expedition obtained their own insurance. The primary companies used were: British Caving Association foreign cover; Divers Alert Network (DAN) and Snowcard (expedition level). Costs ranged from annual cover (£250) to individual trip cover – caving and cave diving (£60).
The policies covered decompression sickness, diving related illness, caving injuries and rescue. European cover for EHIC was also still valid.
All insurance was self-funded, and no claims were made.

Travel and Transport

Christine and Richard drove from the UK to Croatia, transporting most of the team's

cylinders and all other equipment.
The British support divers flew from the UK into Pula. Luke Brock drove from a preceding trip in Spain. Mauro and Osama shared a car from Italy.

Food and Accommodation
The team who flew in directly were picked up by other team members from Pula airport used a rental car to get to Fuzine.
Accommodation was arranged in Fužine, which encompassed 2 houses next to each other. The accommodation had a large outside area for managing drying gear, fixing dive equipment and parking. It had bathrooms, kitchens, dining space and plenty of power outlets.
Food was purchased from the local village supermarket and on occasion the team ate at the local pizzeria, in addition to a few other local restaurants. Local tap water was potable.

Communications
The team leader communicated via email prior to the expedition to arrange permits, accommodation and chaperone. Internet in the region has improved and fast wifi is now available in the accommodation.
Trello was used for pre-expedition planning and a team Whatsapp group was set up for communications between the group on site.

Specialist Equipment
All cave diving expedition equipment is specialist and adapted for the environment which is unique.
The closed-circuit rebreathers and scooters (Suex XK1) were the most specialised as they needed to have adequate scrubber time and be compact enough to carry through the cave. The scooters needed to have enough battery range for several dives and be fast enough to cross the second sump without incurring much or any decompression.
The Suex XK1 scooters fitted this purpose perfectly and the carry packs specially designed for carrying these scooters on the back, were excellent and only needed minor modification to stop them slipping.

Risks and Hazards
Cave Diving is an inherently risky activity, but this is relative and dependent on experience and risk mitigation.
As sump 2 is cold and was expected to be extended even further, risk of decompression sickness is always a real concern. Each diver on the expedition is aware of how to recognize and treat DCI and the nearest recompression chamber is in Rijeka which is a 1-hour drive away.

The biggest risk to the expedition was rainfall and the effect this would have on the visibility in sump 2. This would be problematic as the divers needed the ability to scooter and poor visibility would prevent this or slow down the transit time to and from the point of exploration. This would have a knock-on effect to the amount of bail out gas they would need to carry.

Medical Arrangements
Expedition leader Christine Grosart is an HCPC registered Paramedic and offshore diver medic. She brought sufficient medical equipment such as suturing kits, splints, pain killers, basic airway resus kit, cannulation pack and fluids and trauma kit. All members of the expedition have experience of cave rescue and first aid qualifications.
An oxygen therapy set was available on site.
Good mobile signal was available outside the cave on site.

Environmental and Social Impact
The water from Izvor Licanke resurgence is used for providing drinking water to the local

town of Fužine, prior to processing. This requires special government permits which are managed by Mr Verzic.
Divers and cavers upstream of the resurgence inevitable cause some turbidity by disturbing sediment.
This has not appeared to have caused any problems for the water supply.
The team recycled all possible waste using the receptacles at the accommodation and left no trace in or outside of the cave following the expedition.
The team has a good relationship with the local water plant and has even photographed and changed underwater filters for them at their request.

Photography and Videography
Mark Burkey is an award-winning cave photographer and he was invited onto the project to document it and was trained to cave dive in order to do so.
Christine Grosart is an underwater videographer and filmmaker and has made a documentary style film about the project. The film was premiered in 2018 at the Kendal Mountain Festival.
The Master Cave: Film on Youtube

Media is a very important part of the project for many reasons, not least because there are so few female cave divers running their own expeditions worldwide and leading original exploration themselves.
Excellent images of the project can be found here: Izvor Licanke Project Images

Methods
DSLR cameras needed to be dived through sump 1 in dry tubes/peli cases and then re-packed into more manageable camera boxes on the far side.
Likewise, flash guns and bulbs for still images needed to be kept dry and protected from damage or water ingress.
Underwater video cameras (Paralenz) are depth rated, likewise the underwater video lights which required protection but could get wet without issue.
The dive base at sump 2 was well lit by 50,000 lumen video lights (as used in National Geographic cave shoots).

Media
Images have been used in conjunction with articles on the project in the following publications:
Diver Magazine / Divernet - The Exploration of Izvor Licanke
Descent Magazine
Wessex Cave Club Journal

Talks on the expedition have been given at:
UK Dive show (Dive 2018)
Cave and Wreck Night, Netherlands
Global Underwater Explorers Conference, Florida.
Hidden Earth National Caving Conference, UK
Kendal Mountain Festival
National Geographic - Explore by the seat of your pants - Youth lecture series.

Expedition Diary

Day 1

Monday 20th June 2022
Carry Day.
The team of 8 divers carried 4 rebreathers to sump 2 in buddy pairs, to enable the divers who had not been to this cave before the opportunity to help the divers with rebreathers and also learn the way through the dry cave.
The whole team then returned to sump 1 to begin ferrying all the scooters and some 25 bags through sump one, ready for carrying and chaining to sump 2 which took 6 hours in total.
Learning points: This year due to the excessive amount of bags, we used a magnetic white board and labelled each item and moved it across the board as it entered sump 1.
Unfortunately, whilst this system worked, two bags still managed to escape in the sump but were easily located. A bag tally on the far side of sump 1 would allow these losses to be identified earlier. Simple A4 wetnotes and a pencil is more than adequate.
Hauling scooters up the climb could have been better organized and hauling points discussed beforehand.
What went well: Owing to lack of 'camp boss' the support team batch cooked some food for inside the cave and also for the return to Fuzine as the local restaurants were closed. This was good forethought as the food was badly needed on the exit from the cave and only needed a quick reheat.

Day 2

Preparation day
The exploration divers went through the dive plan and gas logistics and 'what if' scenarios for the first 'push' day.
Final details were organized and timings for crossing the sumps, dekitting, moving equipment through dry cave and rekitting etc were worked out with deadlines for assistance agreed.

Day 3

Exploration 'push' day 1.
The whole team entered the cave at 08:00am and the four deep divers headed into sump 2 in drysuits with rebreathers, additional cylinders and safety bottles, surveying equipment, line reels and scooters at just after 9am.
They dived across in pairs about 20 minutes apart. Osama and Christine dived together first taking the extra gas for the exploration of sump 5 and the spare, back up scooter.
Richard and Mauro followed, dropping one safety cylinder at the shallowest point of sump 2, roughly half way and dropping some 'comfort' markers on the existing line for better reference when crossing the sump.
They also dropped off decompression bottles at 6 metres and 21 metres on the 'home' side of sump 2.

Osama and Christine carried their rebreathers to sump 3 after Christine created a 'washing line' at the end of sump 2, to prevent divers hanging heavy equipment on the already tired dive line. This worked well and there is now a more robust gear storage place for multiple divers.
Richard and Mauro helped carry equipment to sump 3 and Christine and Osama continued forward with a rebreather and 3 bottles each.
They passed sump 3 and then sump 4 before undertaking a relatively easy walk to sump 5, through the passage discovered in 2021.
The divers kitted up for the exploratiuon of the undived sump 5. Christine laid the line initially while Osama dived behind surveying with the Mnemo device.
The sump started off large, following a gravel slope steeply down to 15metres depth. The passage was on average about 10 metres wide and 10 metres high. The visibility was extremely clear, in excess of 10 metres.

Osama searched out the continuation which seemed to be going upwards. Christine handed the line reel over to Osama and he took it up into the roof to continue laying line as the cave continued very shallow. He came across two big airbells which were not the continuation. He tied off the reel at 4m depth with ongoing passage ahead after a 40 minute dive, surveying the line on the way back. Christine filmed the exploration on her Paralenz Vaquita camera, which was mounted on her helmet. In total, 215 metres of line was laid in sump 5 with a maximum depth of 16 metres. The passage generally trends north east.
The divers were met on the return at sump 3 by Richard and Mauro who had kept themselves busy investigating smaller side passages that were well decorated with speleothems.
The dry passage between sumps 4 and 5 that was discovered in 2021, was surveyed as 45 metres in length, using a disto x survey device and topodroid software.
The section of underwater passage in sump 4 that was discovered in 2021 was also re-surveyed with the Mnemo device and this actually added 12 metres to the known sump length. The survey data has been updated accordingly. This brings the total length of the Licanke system to 1.8 kilometres at this stage.

Day 4
Rest Day
Day 5
Rest Day
Day 6
Exploration Push Day 2.
Push divers: Osama Gobara and Mauro Bordignon.
The two divers went straight to sump 2 with their rebreathers. They kitted up and passed sump 2 quickly before passing sumps 3 and 4 until the end of line in sump 5.
Osama was surveying with MNEMO while Mauro laid line. They both surfaced after only another additional 30 metres which marked the end of sump 5.
The divers continued ahead, wearing all equipment to pass sumps 6, 7 and 8 which were interspersed with large air-bells and sand banks which needed to be negotiated.
Before finally ascending in active streamway, Osama de-kitted and Mauro walked ahead wearing his rebreather expecting another sump. He returned after 2 minutes walking stating that the passage continued dry, was of a huge scale and there was no more diving as far as he could see.
Both divers walked upstream through tall canyons, active streamway and big breakdown chambers some 20m wide and 30m high.
They estimated half a kilometre and finally rejoined waist deep water which ended in another sump, which is now sump 9. This is still undived.
The divers did not have any dry survey equipment so estimated the passage dimensions and distance above water. They did however film using a go pro and shot good footage using underwater video lights to light up the cave passages.
The divers were underground a total of 15 hours.

Day 7
Rest Day
Day 8
Rest Day
Day 9
Rest Day

Day 10
Exploration Push Day 3
Osama and Mauro returned to their limit of exploration to undertake a dry cave survey in the big canyon and chambers beyond sump 8. To do this they used a Disto X and Galaxy phone with Topodroid survey software.
They filmed the majority of the passages beyond sump 5 using Go Pro and Paralenz cameras.
Mauro investigated sump 9 with just a mask and torch, but no attempt was made to dive it as this would have exceeded the time scale allotted for this exploration.
The divers were given some glass sample bottles to collect water and sediment samples from the further reaches of exploration. Local specialists kindly offered to analyse rock samples and conduct microplastics analysis of the water. Samples were taken from Sump 2, sump 4 and sump 9.

The divers were underground a total of 17 hours and were met by the support team on their exit at sump 1.

Conclusion

At the beginning of the expedition it was assumed that the cave may start to slow down, as it became more ‘multi-sump’.
Whilst it did indeed become more multi-sump, this led to significant discoveries of dry passages, canyons and enormous breakdown chambers.
Two of the team ventured up onto the mountain to locate the exact spot where the survey currently ends, at ‘Wild World’ and the undived sump 9.

Figure 16 Dense forestry above the large chamber 'Wild World'.

This was in thick forestry, with a dense layer of undergrowth and no obvious sign of a surface entrance, although this would be extremely difficult to see. There are no known cave entrances on this particular plateau.

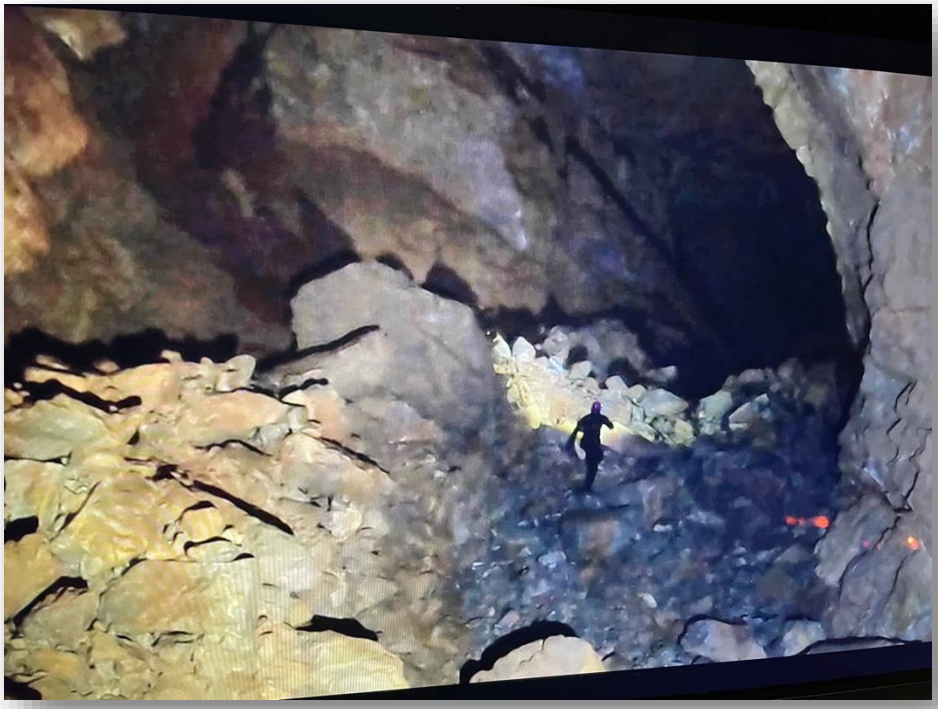

Figure 17 'Wild World' screen grabbed image from Go Pro video.

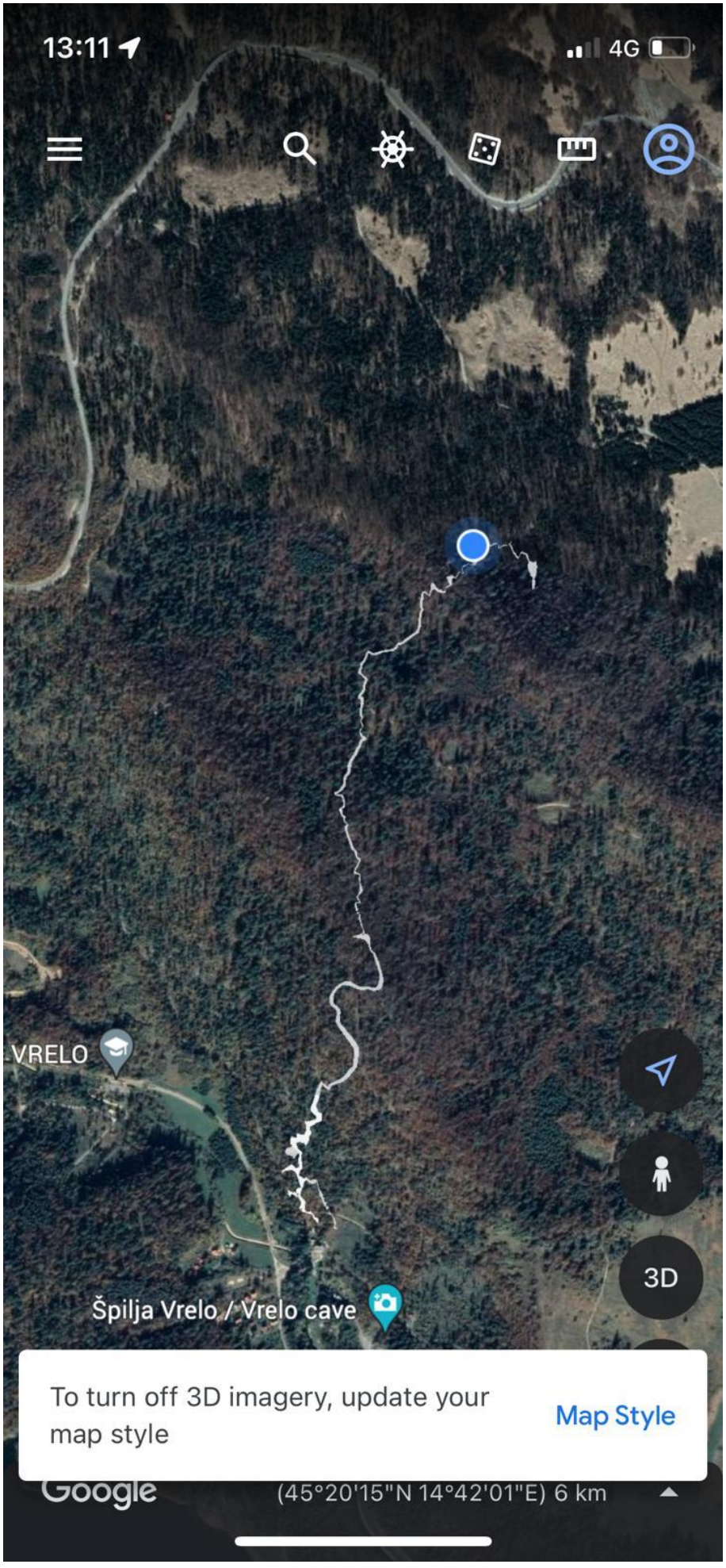

Figure 18Google Earth Pro survey overlay of Licanke on surface topography.

Acknowledgements

Ghar Parau Foundation http://www.gharparau.org.uk/
Mount Everest Foundation https://www.mef.org.uk/
Santi Drysuits
Suex Scooters https://www.suex.it/
Halcyon Dive Systems http://www.halcyon.net/
Warmbac

Appendices

Example of Team packing List:

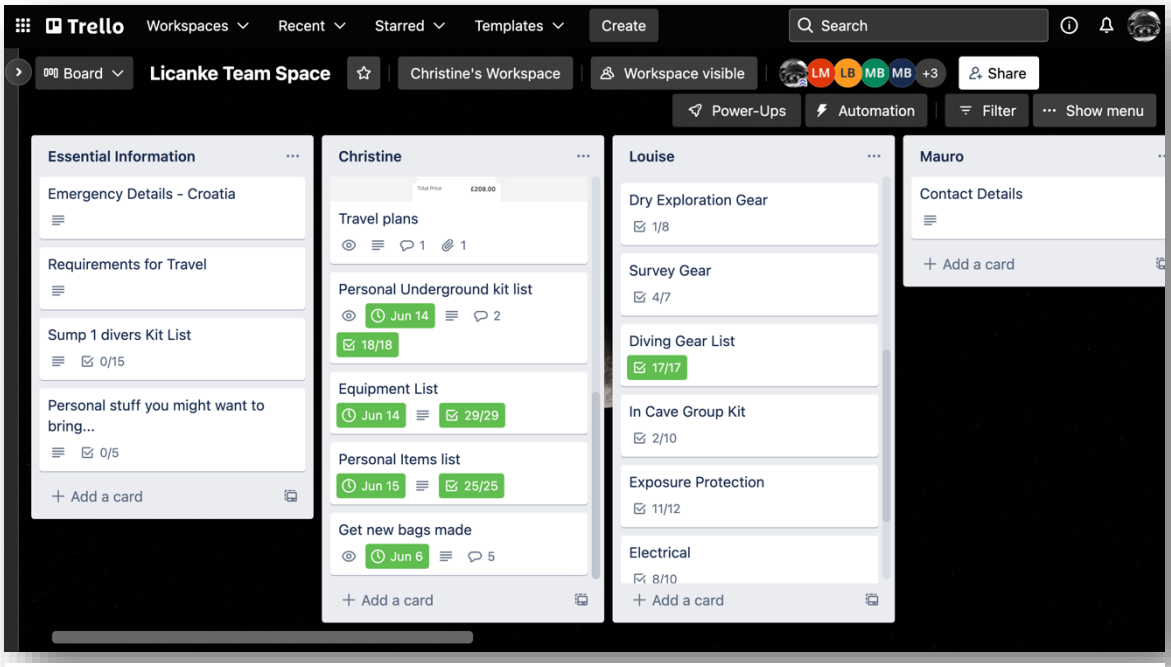

Figure 19 Packing lists in Trello.

Web Links

Descent magazine	Centre Spread
Diver magazine	Article
The Master Cave	Film Link
Film Trailer	The Master Cave: Trailer
WetWellies Caving	Blog

Distribution list

Ghar Parau Foundation
Mount Everest Foundation
Royal Geographical Society
Cave Diving Group Newsletter

Bibliography

Plongeesout https://www.plongeesout.com/
Cave Diving Group Newsletter https://cavedivinggroup.org.uk/newsletters/

Glossary of caving and cave diving terminology.

Bailout: Open circuit cylinders used to breathe in an emergency should the diver's rebreather malfunction.

CDG: Cave Diving Group (Great Britain). One of the oldest diving organisations in the world, the CDG was formed in 1946 for the purposes of cave diving in Great Britain and training divers and cavers to explore underwater caves.

Disto-X: Digital cave surveying device

GUE: Global Underwater Explorers. Nonprofit diving training organization, originating in the United States with cave diving and now globally at an internationally renowned high standard.

HCPC: Health Care Professions Council

IANTD: International Association of Nitrox and Technical Divers. Technical and cave diving training agency

KISS: KISS rebreathers; brand name of a model of manual rebreather, built in the USA.

Open Circuit: SCUBA (self-contained underwater breathing apparatus).
Breathing gas compressed to approximately 200 x atmospheric pressure is delivered to the diver via a pressure reducing valve. The diver inhales from a mouthpiece and exhales into the water via the same mouthpiece.

Rebreather (Closed Circuit Rebreather/CCR): Machine that recirculates the divers breathing gas, instead of venting every exhaled breath into the water. This significantly improves efficiency over regular SCUBA but comes with the risk of increased complexity.

Scooter: Diver Propulsion Vehicle (DPV). Torpedo shaped machine with a propeller, that tows a diver along at greater speed then they could swim. This reduced the amount of effort and time in covering distance underwater and this in turn reduces the amount of time spent at depth, thus reducing decompression obligations.

Sidemount: British Cave Diving technique of mounting diving cylinders on the side of the divers body rather than on the back, to enable passing small underwater passageways.

Sump: Completely flooded section of cave passage, which requires diving to pass.

Twinset: Two cylinders tied together, worn on the divers back and manifolded together.

Tackle Bag: Heavy duty PVC coated cordura bags designed specifically for carrying loads through caves.

Regulator: Device that reduces cylinder pressure to ambient pressure enabling the diver to breathe from it.

WKPP: Woodville Karst Plain Project. Cave exploration project in the USA, comprising the famous Wakulla Springs.