

# Cave Diving Exploration

Izvor Licanke, Fužine, Croatia  
2021 Report

21<sup>st</sup> August 2021 - 30<sup>th</sup> August 2021

Cave Diving Group  
Great Britain



*Image: Mark Burkey*

Detailing the 2021 cave exploration and documentation of Izvor Licanke.  
2021 publication.

Report: Christine Grosart, 2021. [christine\\_grosart@yahoo.co.uk](mailto:christine_grosart@yahoo.co.uk)  
[www.wetwelliescaving.com](http://www.wetwelliescaving.com)

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*Team Izvor Licanke Expedition, 2021. Images: 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 sixth 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.

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.

This expedition had to be cancelled due to the covid-19 pandemic on two occasions prior to this expedition finally going ahead.

## **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.

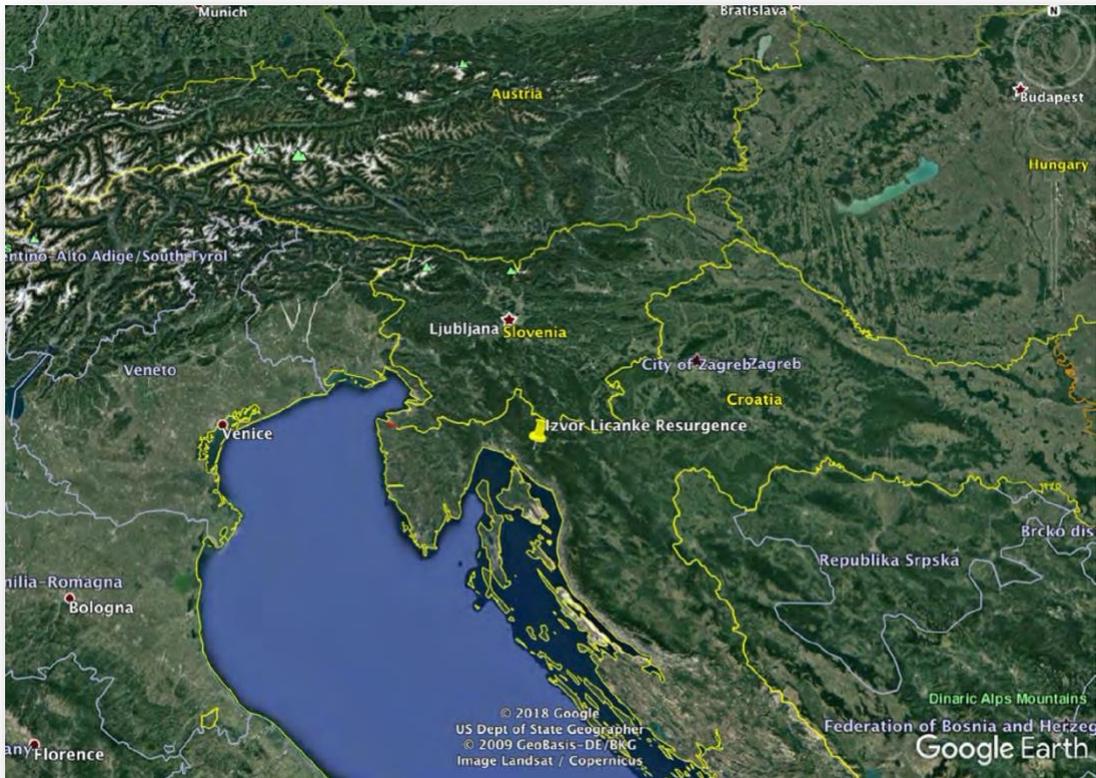


## Location and Maps

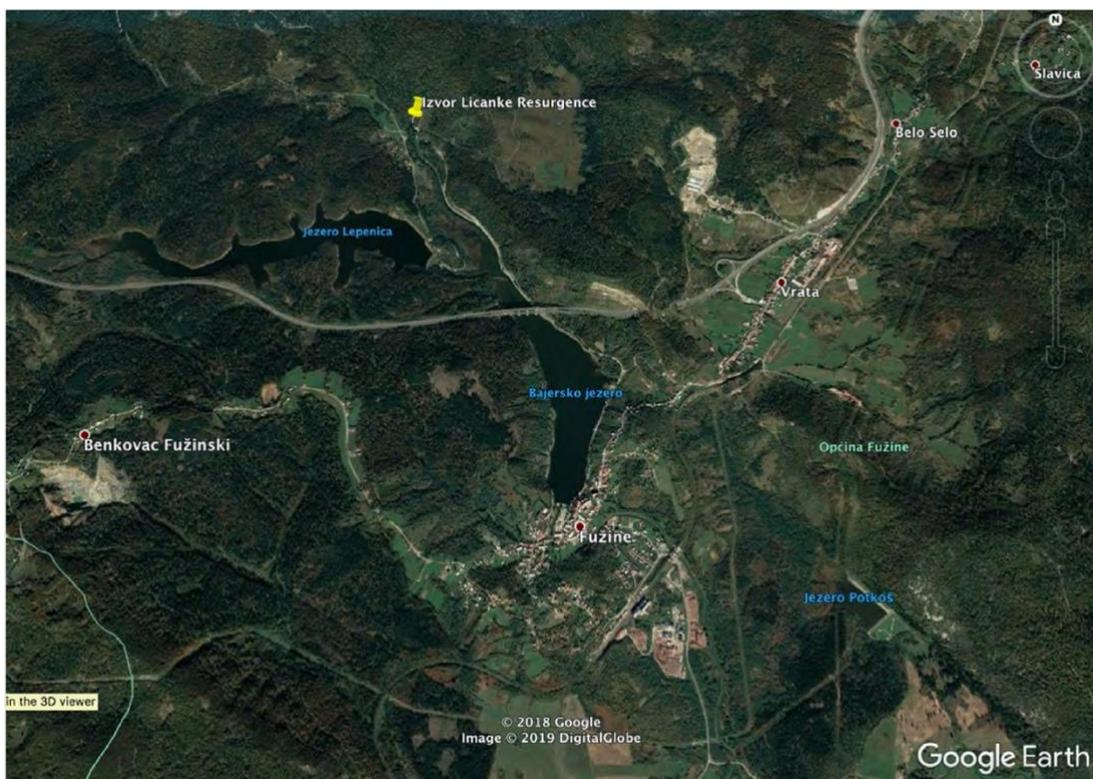
Izvor Licanke resurgence.

Latitude: 45° 19.720'N Longitude: 14° 42.094'E

Country: Croatia. Town: Fužine



Map source: Google Earth Pro™

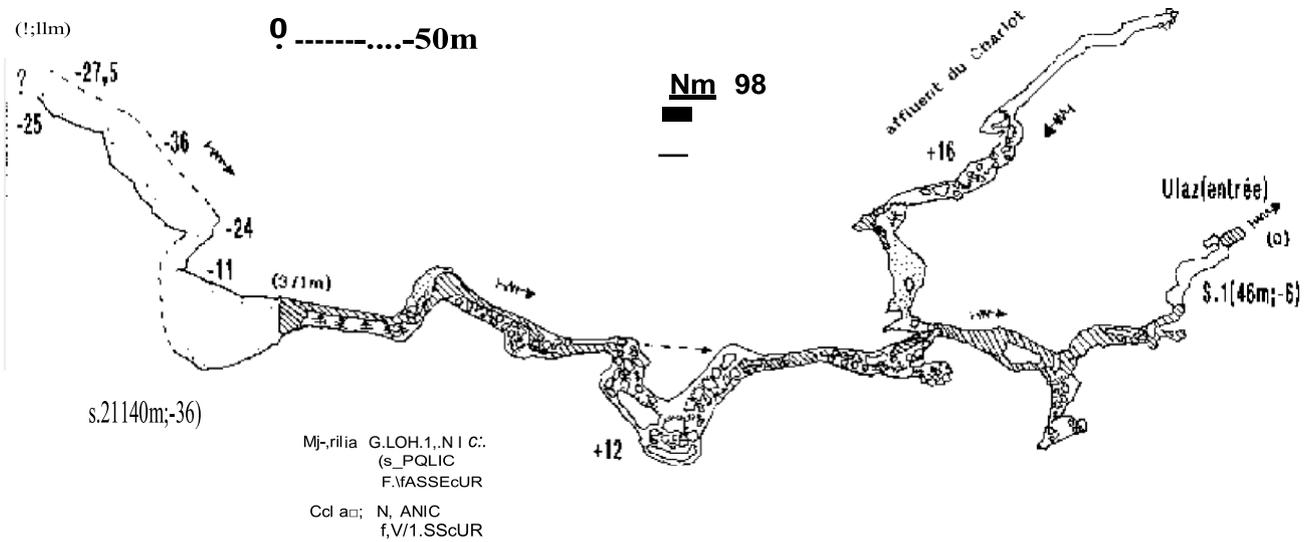


# IZVOR LICANKE

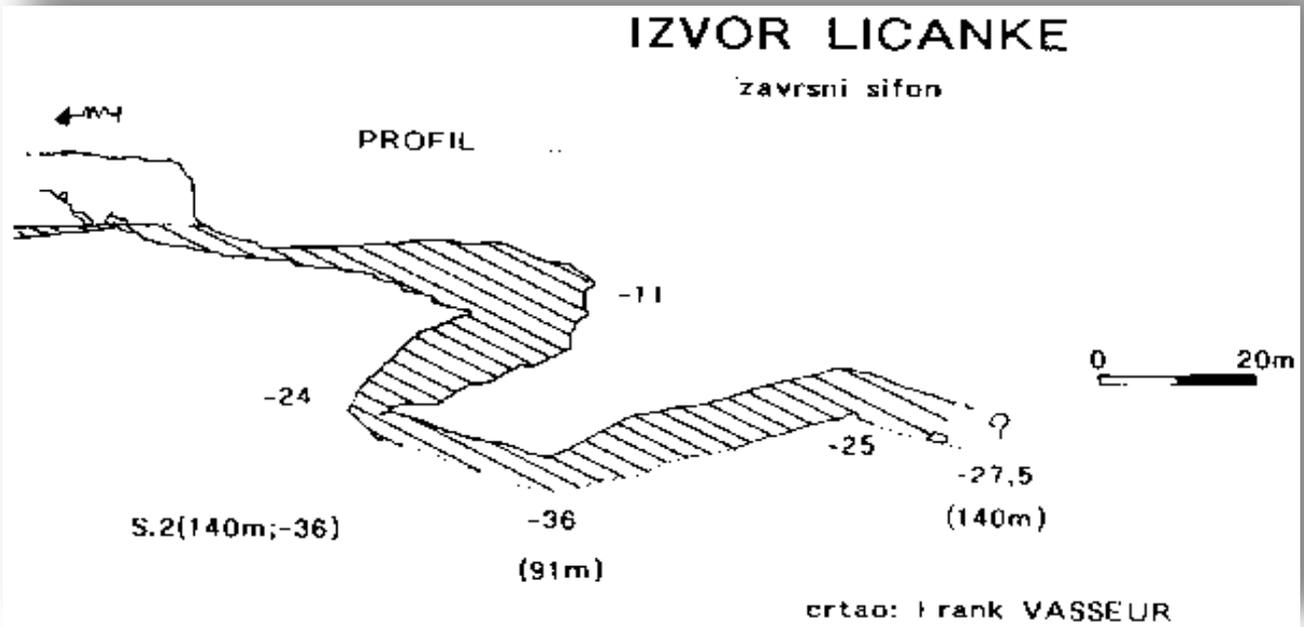
FUW E - GORSKI KOTAR

Dubina: 831 m  
 Dujina: 50m (-34; 16)

## TLOCRT (PLAN)

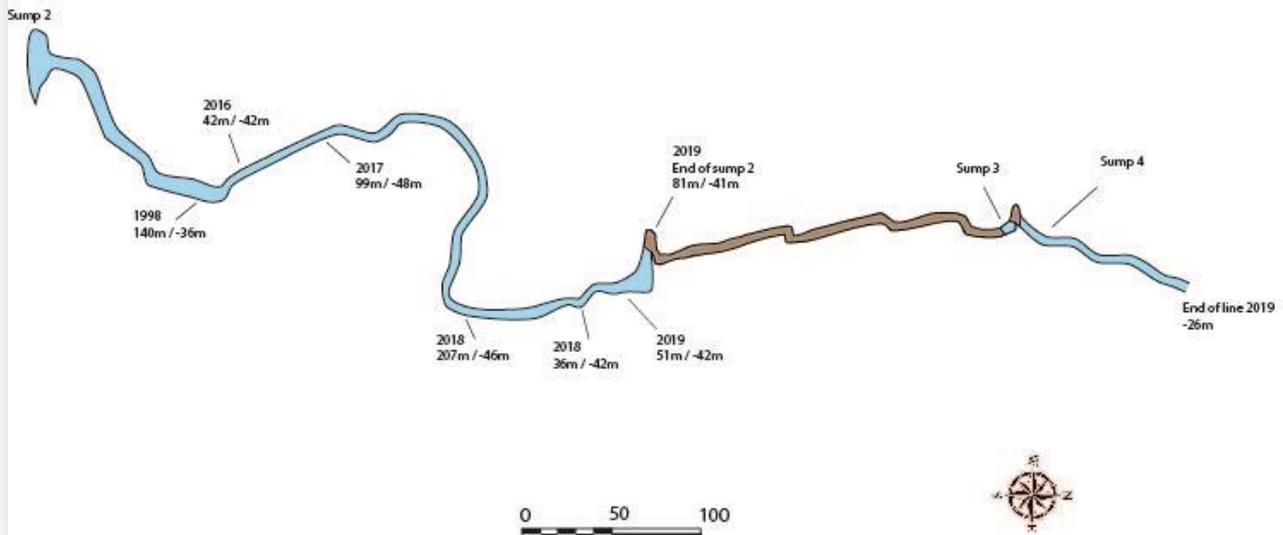


1998 Survey of Izvor Licanke, sump 1 leading to sump 2. Source: *Plongeesout.com*

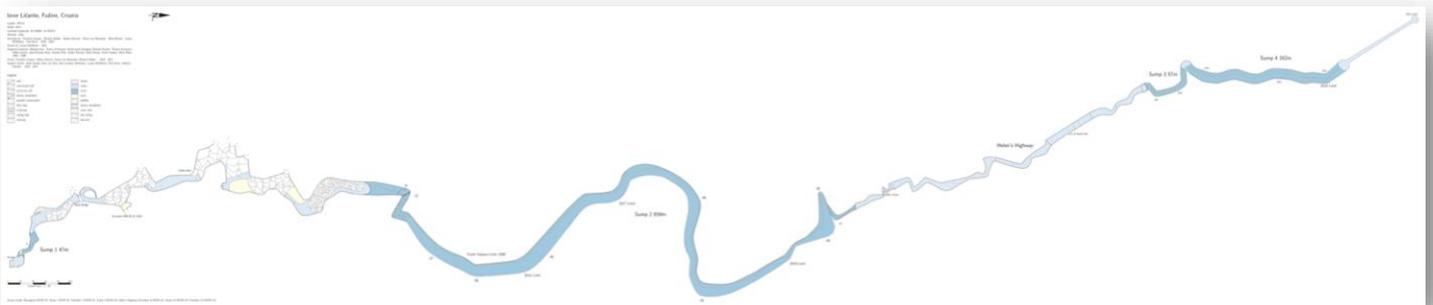


1998 Survey of Izvor Licanke, sump 2. Source: *Frank Vasseur; Plongeesout.com*

Izvor Licanke, Fuzine, Croatia. Sump 2, Plan Survey, 2019  
 Exploration:  
 Frank Vasseur (FR) 1998  
 Christine Grosart 2016-2019  
 Richard Walker 2016-2019  
 Ash Hiscock 2018 - 2019



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



**Survey of Izvor Licanke, full cave center line to 2021 terminus.**  
*Source: Louise McMahon (GB)*

## **Expedition members 2021**

### **Christine Grosart**

(Great Britain)

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

22 years caving experience

17 years cave diving experience

12 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

### **Richard Walker PhD**

(Great Britain) 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**

(Great Britain) Support/Video/Images

Rope access Level 3

Caving for 11 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**

(Great Britain)

Support / Survey

Caving for 3 years

Cave Diving Group member

Caving clubs: Technical Speleological Group, Northern Pennine Club.

Dry caving exploration in the UK. Licanke is first expedition

### **Fred Nunn**

(Great Britain)  
Support / Survey  
Diving for 20 years  
BSAC 60m trimix and instructor  
Relatively new to caving  
Licanke is first expedition

### **Anton van Rosmalen**

(Netherlands)  
Exploration Diver / Survey  
Years Caving - 15  
Years Diving - 30  
Diving Qualifications - GUE Cave2, GUE Tech2, GUE DPV2, GUE Rebreather  
Occupation - Offshore Risk Engineer  
Clubs/Associations VVS/TRT  
Expeditions of note: Event de la Coudoulière Exploration Project; MCEP; EKPP; Project MARS the Magnificent; Project Morpheus; GUE Project Baseline Mediterranean Expedition.

### **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 lay 1496 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. Mark Burkey was put in charge of 'base camp' at sump 2 as well as photography and videography. Contacts from Krnica Dive arranged the government permits and made arrangements for his dive centre to loan the cylinders required and fill them with the specified gasses. Richard Walker assisted with a back-up Suex scooter, kindly loaned by Adam Hanlon. Contacts from Krnica Dive kept in contact with the water board at Fužine for regular updates on weather conditions and water levels at the cave.

## Aims

The aim of this year's project was to continue exploring the ongoing cave system in sump 4 and beyond and to survey the new cave passages from 2019 to grade 2 or 3. In addition, as with every expedition here the intention was to document the mission using underwater video and cave photography.

## 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  $\pm 2.5^\circ$ ; distances measured to  $\pm 50\text{cm}$ ; station position error less than 50cm after closing loops. Compass calibration taken from local magnetic variation.



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

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.

This year 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.

## 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:

**Divers:** Christine Grosart; Anton Van Rosmalen.

**Total new cave explored in 2021** (centerline): 104 metres

**Total Cave Length** now stands at: 1623m (centerline distance only)

**Total Cave explored by UK team since 2015:** 1229 metres.

**Water temperature:** 7 degrees C

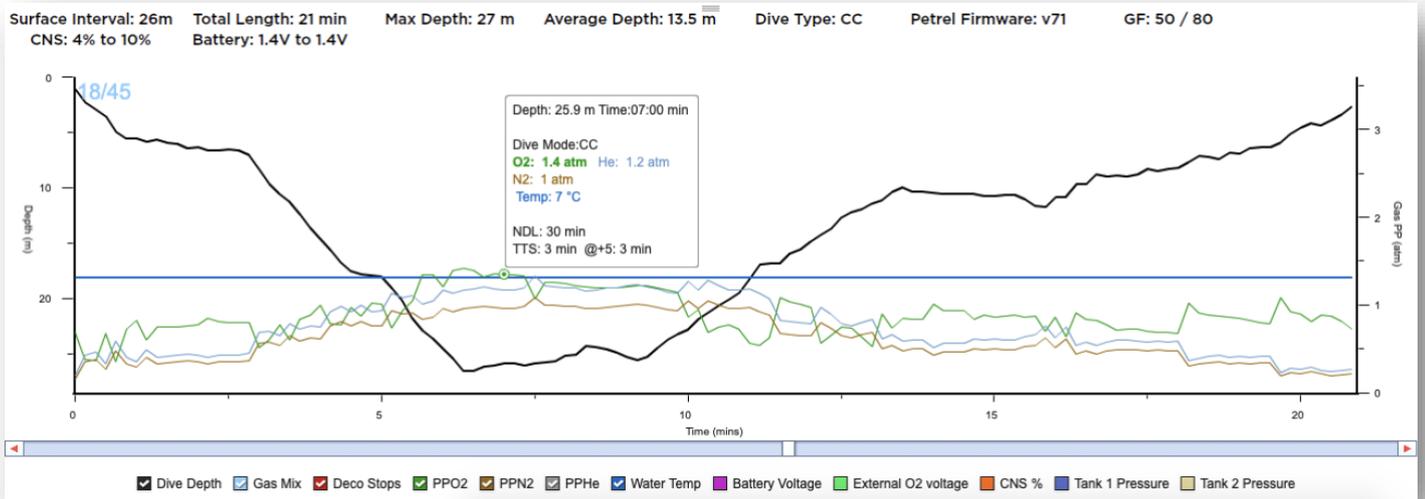
**Visibility in sump 2:** 6 metres and a little milky.

**Visibility in sump 3 and sump 4:** 8 metres.

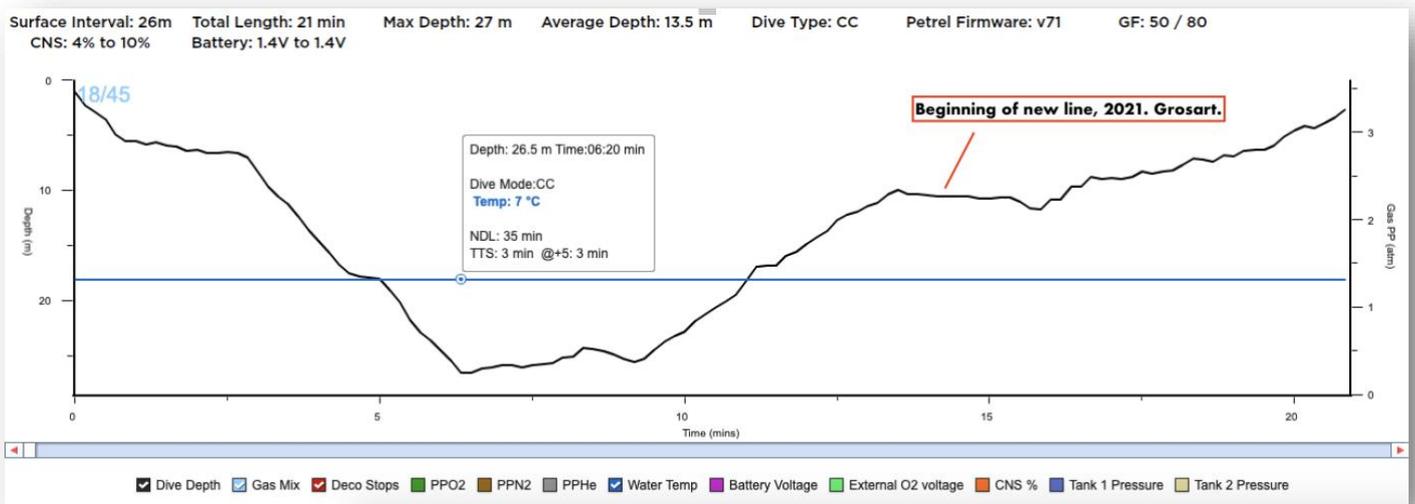
Surface weather was about 18 degrees and sunny/cloudy for most of the week with the occasional rain overnight, but this did not seem to affect the underground conditions, probably due to the extensive vegetation on the surface above the cave.



*Support divers Louise and Fred prepare cylinders and camera equipment at sump 2 base camp. Image: Mark Burkey Photography.*



**Profile of dive in sump 3, inward dive.**  
 Diver: Christine Grosart. Computer: Shearwater Petrel 1



**Profile of exploratory dive in sump 4, inward dive.**  
 Diver: Christine Grosart. Computer: Shearwater Petrel 1

## **Project Modifications**

This was a smaller team than usual on this expedition, mainly due to COVID travel restrictions. This meant that we could not afford to lose any single one member of our team to injury illness or any other factor.

On the day of the first push dive, Richard declared that he was feeling unwell and was becoming short of breath whilst caving in relatively easy passage in his dry suit.

This meant that Christine was unable to pass sump 2 with the amount of bailout cylinders required to explore beyond some 4. Teamwork was required to move enough bailout bottles as well as the spare scooter another spare gas. Christine modified the plan quickly and planned to dive alone through sump 2, to investigate the passage beyond that she had yet to see.

Richard and the rest of the team repeatedly tested negative for COVID-19, but Richard was too unwell to assist with the rest of the expedition until the final equipment recovery day.

This meant that two of the exploration days were put back and the schedule was re-formed on a day-by-day basis. What allowed us to do this, was the insertion of a rest day in between each push day.

Once Christine had dived sump three by herself, she was limited in the amount of bailout that she could carry, in order to go any further. She was aware of another exploration diver with the capability of exploring this cave. In fact, he had first visited this cave in 2015 when the team first started investigating it. Anton Van Rosmalen was in the south of France on another cave diving expedition so Christine called him and asked if you would like to join the Licanke team.

Anton agreed and drove 14 hours to Fužine, and took a day to prepare, carry in his rebreather, and allow some rest before the exploration dive.

## **Discussions and conclusions**

The team held a group washup meeting which Louise ran to great effect. The format covered what went well, what didn't go well, and what could be improved. Each team member went around the room to comment on each topic. There were many improvement suggestions although most of these were based around such a small team in many cases struggling with a mammoth task. The planning had not been ideal due to COVID restrictions changing daily and the expense of travelling abroad skyrocketing. Things like planning COVID tests for travelling where a headache and an unwelcome expense.

It was agreed that a much bigger team and much more time was required on the next expedition. The push divers require a minimum of two days off in between explorations as these were now going to be in excess of 14-hour days underground.

In terms of communications prior to the trip a Facebook group was used but the team pointed out that sometimes they would miss notifications. So, a more organised planner was suggested such as Trello that the whole team could use so that everybody knew what their role was.

It was also suggested that an expedition project leader could be somebody that was not an exploration diver so that the lead divers could concentrate on the job in hand and not have to worry about things like COVID tests or travel arrangements.

## 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

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.

## Water level data example image from the 2018 expedition.

	A	B	C	D	E
63494	8.6.2018. 20:14:52	19			
63495	8.6.2018. 20:20:19	19			
63496	8.6.2018. 20:25:47	19			
63497	8.6.2018. 20:31:14	19			
63498	8.6.2018. 20:36:42	19			
63499	8.6.2018. 20:42:10	19			
63500	8.6.2018. 20:47:37	19			
63501	8.6.2018. 20:53:05	19			
63502	8.6.2018. 20:58:32	19			
63503	8.6.2018. 21:04:00	19			
63504	8.6.2018. 21:09:28	19			
63505	8.6.2018. 21:14:55	19			
63506	8.6.2018. 21:20:23	19			
63507	8.6.2018. 21:25:50	19			
63508	8.6.2018. 21:31:18	19			
63509	8.6.2018. 21:36:46	19			
63510	8.6.2018. 21:42:13	19			
63511	8.6.2018. 21:47:41	19			
63512	8.6.2018. 21:53:08	19			
63513	8.6.2018. 21:58:36	19			
63514	8.6.2018. 22:04:04	19			
63515	8.6.2018. 22:09:31	19			
63516	8.6.2018. 22:14:59	19			
63517	8.6.2018. 22:20:26	19			
63518	8.6.2018. 22:25:54	19			
63519	8.6.2018. 22:31:22	19			
63520	8.6.2018. 22:36:49	19			
63521	8.6.2018. 22:42:17	19			
63522	8.6.2018. 22:47:44	19			
63523	8.6.2018. 22:53:12	19			
63524	8.6.2018. 22:58:40	19			
63525	8.6.2018. 23:04:07	19			
63526	8.6.2018. 23:09:35	19			
63527	8.6.2018. 23:15:02	19			
63528	8.6.2018. 23:20:30	19			

*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 CO<sub>2</sub> the softlime 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 and Ash Hiscock always prefer to use 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.

### 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.



*Christine and Suex scooter. Image: Richard Walker*

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.

### Fund Raising 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 £400.00

Mount Everest Foundation granted an award of £1750.00

The remainder of the expedition was self-funded by the individuals on the team.

### Summary of costs:

	Travel	Accommodation	Covid Tests	Food	Logistics
Christine	£376.45	£224	£136	£200	Rental Van £1100
Richard	£376.45	£332.86	£136	£200	Permits, Local Logistics £700
Ferry	(£375)				Diving Gas/Cylinder rental £275
Fuel	(£240)				
Tolls	(£137.90)				
Mark Burkey	£356.28	£224	£136	£200	
Louise McMahon	£356.28	£224	£136	£200	
Fred Nunn	£191.62	£224	£136	£200	
Anton Van Rosmalen	£88.62		£68	£40	
Total	£1745.70	£1228.86	£748	£1040	£2075

Total cost of expedition: £6837.56

Total Funding: £2150.00

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

Mark Burkey, Louise McMahon and Fred Nunn flew to Pula from the UK. Christine Grosart together with Richard Walker drove from the UK to Croatia and took some items for those that flew.

Anton Van Rosmalen drove from the Herault region of France in 14 hours to Fužine.

Velimir Vrzic lives in Croatia and drove to the cave himself.

Diving cylinders were collected from Krnica dive centre and driven to the cave location. All diving equipment was moved to and from the site using personal vehicles and a rental van.

### Food and Accommodation

The team who flew in directly were picked up by other team members from Pula airport and shared transport with the team who had vehicles to Fužine.

Accommodation was arranged in Fužine, which is a wooden hunting lodge, with ample rooms for up to 10 people.

The accommodation has a large outside area for managing drying gear, fixing dive equipment and parking. It has 2 bathrooms, a kitchen, large dining room and plenty of power outlets.

Food was purchased from the local village supermarket and most evenings were spent in 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. At present, mobile data in Europe remains the same as in the UK but following Brexit, this is highly likely to change and become expensive in January 2022.

It was noted by the team that the private project Facebook group was not efficient as many of the team did not receive notifications of updates. The team is likely to be larger in 2022 so Trello will be used for planning with email alerts to relevant 'cards'.

## 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.

The team were offered the loan of a [Mnemo](#) underwater surveying device at the last moment. Richard Walker made a lot of effort to learn how to operate the device as his job was to be survey, but unfortunately, he was unable to embark on the exploration due to illness, so the device did not get used.

## 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. The local water board were very helpful and sent the team images of the resurgence pool and water levels data and a decision to go ahead was made only 4 days prior to the trip beginning.

## 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.

One individual became ill but tested repeatedly negative for Covid-19, as did the rest of the team. One individual briefly sustained a twisted knee when a piece of rock broke under them. They were able to continue caving and no lasting damage sustained.

## 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: Trailer

This year, Mark made his first dive into sump 2 to place decompression bottles and to film the push divers setting off into sump 2. Mark is relatively new to underwater photography, so this was an opportunity to widen his skill set and, as he was warned, empty his bank account!

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 underwater camera and lights were mounted on a specialised scooter mount made by Suex™.

The dive base at sump 2 was well lit by 50,000 lumen video lights (as used in National Geographic cave shoots) so photography could be far more 'candid'.

## 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**

**21st August 2021**

The team arrived at Krnica dive centre and began preparing diving equipment. This is where the diving cylinders were rented and filled to requirements. The exploration divers built, checked and tested the rebreathers.

All diving gasses were labeled, analysed for oxygen and helium content and regulators tested in water. The cylinders were placed in tackle bags ready for transporting through the cave. The dry tube was packed and weighted for transportation through the first sump. This was to keep 'dry' gear dry such as warm clothing, food and camera equipment.

The team then travelled in the afternoon up to Fužine.

### **Day 2**

**22<sup>nd</sup> August 2021**

**Set up day.**

All the equipment was lined up at the cave entrance and a washing line installed in the first sump to clip everything to, preventing it floating away or sinking.

The water levels were extremely low in comparison to all previous years, this undoubtedly due to the time of year.

This made lowering equipment into the first sump a little tricky and more time consuming than it should have been.

Equipment made its way through sump 1 but the usual plan of scooting it across the lakes on a life raft was thwarted. The water levels were so low that each bottle bag and tackle bag and scooter and rebreather had to be carried individually which was far less efficient than towing 4-5 bags across the lakes in one go.

Getting all the equipment up the climb and over the boulder pile was also time consuming as the chain only consisted of 5 people, one of who was very inexperienced and the other had not been in this cave before.

This was a result of the covid pandemic as we were unable to gather enough experienced cavers due to last minute change of dates and short notice.

The base camp was set up at sump 2 and Fred was tasked with checking all the bottles for damage and leaks. Some leaks were identified at the cylinder necks and a pressure gauge, and a few regulators needed to be switched out.

### **Day 3**

**23<sup>rd</sup> August 2021**

**Rest/survey preparation Day**

After a tiring carry, the team took a rest day to prepare for push dive 1. Regulators were fixed, line was loaded onto reels and survey practice with the Mnemo was undertaken.

Louise offered to conduct a centre line survey of the main dry passage and lakes between sumps 1 and 2. This was a blessing as the original data was not obtainable, being over 20 years ago and it needed to be done again properly. Louise has a lot of skill with Therion and would be able to draw up a new, accurate survey from the entrance to the current terminus of the system. She took this opportunity to train Fred and Mark in dry cave survey techniques.

**Day 4**  
**24<sup>th</sup> August 2021**  
**Push Day 1**

Christine and Richard got into their dry suits and set off into sump 1. Christine was moving well through the cave when she was called back by one of the team. Richard was very breathless, felt exhausted and was certain he could not continue. He had developed a new cough and it was accepted that he could not continue.

\*He subsequently tested negative every day for covid-19 as did the rest of the team.

Christine continued caving to sump 2 and pondered what to do.

The loss of a diver meant a reduction in the amount of bailout cylinders that could be ferried through sump 2. Christine was already set to tow a back-up scooter and was already carrying two bailout bottles, plus suit inflation gas and a spare oxygen bottle. There was no space or capacity to take more gas whilst solo.

She changed the plan to suit the situation. She would dive solo to the end of sump 2 and de-kit. She had never seen the passage beyond sump 2 so it was important to get familiar with that. She would then look at sump 3 and decide whether to dive it. She did not have enough bailout gas to proceed further than sump 3.

Thus, the push dive was reduced to a reconnaissance dive. Christine passed sump 2 without issue and alone, carried her rebreather, one bailout bottle, suit inflation bottle and fins in 3 journeys to sump 3. It took roughly 15-20 minutes each way between sumps. The carry involved one awkward boulder choke, some walking, some stooping, a little swimming but thankfully no crawling!

Once at sump 3, she decided to dive it as she was feeling good and was there now, after all. An easy gravel beach aided kitting up and she set off into sump 3. It took 4 minutes to pass, and it surfaced at a sloping, slippery rock ramp. Knowing she did not have enough bailout to dive sump 4, it seemed pointless de-kitting at this point. The line was tied off high onto the far wall, but a rock flake prevented her from seeing the next sump which was only 6 metres away around a corner.

She dived back through sump 3, carried all her gear back to sump 2 in another 3 journeys and dived home without incident.

Total Dive time: 72 mins

Average Depth: 40m

Maximum Depth: 49m

Mark, Louise and Fred meanwhile embarked on surveying the centre line between sumps 1 and 2 to BCA grade 5. Mark and Fred learned surveying skills brand new to them and Mark also trained them in how to assist with underground photography.

**Day 5**  
**25<sup>th</sup> August 2021**  
**Rest day**

It was concluded without doubt that a solo diver beyond sump 2 was not a sensible plan moving forward, especially when no other team member could pass sump 2.

Richard was still unable to dive, so Christine took the bold decision to contact a cave diver she knew was in the south of France at the time, exploring another deep system.

He had his rebreather with him, had visited Izvor Licanke in 2015 passing sump 1 and had more than enough capability to join the exploration.

Christine contacted Anton Van Rosmalen and after an hour of consultation, he confirmed his availability. Christine had dived with him on exploration trips before and they operated well together.

He drove 14 hours from the Herault France to Fuzine. Exhausted, he spent a day preparing his rebreather and equipment for the dive.

## **Day 6**

**26<sup>th</sup> August 2021**

### **Preparation and Survey**

Anton carried his rebreather to sump 2, then left to continue preparing his equipment. Richard was still unable to go into the cave. The rest of the team used their time in the cave wisely and Louise set about putting bolts into the climb to make hauling and lowering easier. Mark did some photography and Christine re-surveyed sump one to complete the centre line survey that Louise was creating.

## **Day 7**

**27<sup>th</sup> August 2021**

### **Push day 2**

The whole team headed to sump 2 and Christine and Anton began kitting up for the push dives.

They transported a small dry tube with them containing dry survey gear in addition to bailout bottles, spare scooter in addition to their own scooters and spare gasses.

The diver surfaced at the far end of sump 2 and began de-kitting and carrying their equipment to sump 3, again taking 2-3 journeys each.

They kitted up at sump 3 and had a pleasant dive through to the exit ramp out of the water. Anton got out of the water first and very quickly found sump 4 which was 6 metres around the corner.

A slightly awkward and sharp barrier had to be climbed over to drop into the water in sump 4.

Anton entered the water first and as he reached up to pick up his bailout bottle, it tipped off the edge of the barrier and hit a rock below. This caused damage to one of the hoses on the bottle.

Anton declared that he could not go any further but should be able to find a workaround for accessing his gas when back at sump 2.

Christine got into the sump and took the 300m line reel which was knotted at 3m intervals. She was aware that the line ended in the sump from 2019 at 10 metres depth, having dipped to 27m depth at one point.

She set off along the very well laid line (admiring the handywork of her ex-trainee) and the dive seemed to go on forever. It was actually only 129 metres before she came to the end of the line at 10m depth. Some excess line was tied into a neat bundle and jammed around and under some rocks.

Christine tied in her line reel to the last tie-off and started laying line through the wide, sizeable passage. Relieved at finally being able to push the cave on, she stayed in the middle of the passage, laying line over the sandy floor and tying off to the occasional decent sized flake of rock. After about 5 minutes of laying line, the cave started to trend upwards and soon she was met with a huge, sheer rockface. After a good look left and right and seeing no obvious continuation, she made her way up the wall, now certain that the sump would soon surface.

This was a tricky maneuver, laying line almost vertically with a smooth wall, managing a manual rebreather and route finding. There were a distinct lack of finger holds on the wall too!

She kept on looking up and soon spotted the glistening ripples of air space.

As she broke surface she banged her (helmeted) head on a roof projection. She moved aside and surfaced in a large, circular airbell. A quick search around the smooth walls found a flak of rock which looked not dissimilar to the one that hid sump 4 from view from the end of sump 3. She swam over to it, still gripping the line reel and found an easy exit and de-kitting spot.

She tied off the line reel in the new passage, plenty far enough in and up high in the case of rising water levels and de-kitted on a comfy rock.

Delighted, she set off down virgin streamway passage, which was in pretty much a straight line and, typically, heading north. It was easy going until she all too soon reached another sump.

She got into the water and searched around the edge of the circular sump to check it was not just a duck. Sump 5 confirmed and with not enough bailout to continue, she took a compass bearing into the cave of 332 degrees (NNW) and paced her way back to the end of sump 4, counting 70 steps between sumps.

She dived home without issue, counting knots in the line as she went through sump 4. She was met by Anton on the home side of sump 4 and they both passed sump 3 also without issue and surfaced in the relative sanctuary of the passage between sumps 3 and 2. They began conducting a grade 5 survey of this passage which took a couple of hours, using a Disto X, Galaxy phone and Topodroid software which had been transported in a small dry tube.

Anton then kitted up first to return through sump 2 as there was only space for one diver to kit up at any time.

Christine then began kitting up only to realise that a free flow in her BOV (Bailout valve) on the rebreather had all but emptied her diluent bottle.

After some thinking, she fabricated a system which ran the rebreather in fully manual mode, reconnecting the hose to offboard diluent on her bailout bottle and had a relatively pleasant dive home, although the team at sump 2 dive base were concerned that she had not appeared when expected behind Anton.

Christine's exploration dive details:

Time underground: 14 hours

Time in water: 124 minutes

Total dives: 8 (4 sumps)

Total cave discovered: 104 metres (grade 1)

Water temp: 7 degrees

Visibility: 10m max (sump 4)

## **Day 8**

**27<sup>th</sup> August 2021**

### **Equipment recovery Day**

Anton had already removed his rebreather the day before, so the remainder of the equipment needed to be recovered from the cave. Mark Burkey made an excursion down to 24 metres in sump 2 to retrieve the bailout decompression bottles and scooters and the team made good time in recovering all the equipment back to daylight in around 6 hours.

## **Day 9**

**28<sup>th</sup> August 2021**

### **Packing day**

Equipment was inspected, sorted, checked for damage and loaded into respective vehicles for their return.

## Conclusion

The expedition achieved the primary aim that was to extend this cave and exceeded expectations yet again by encountering a 5<sup>th</sup> sump.

By its very nature, as the cave gets longer, so does the time underground and the logistics of multi-sump diving beyond a deep sump that requires rebreathers and scooters.

The small team did make the trip significantly harder than all previous years and the loss of a push diver made things even more problematic, with a last-minute decision to bring in another push diver to the team.

This was far from ideal but paid off. The alternative would have been to end the expedition there and then.

Plans for the following year include no less than 4 divers capable of passing sump 2 and a much bigger support team for the carry to sump 2.

The survey effort from the entrance to sump 2 and between 2 and 3 was significant as we now have a complete data set for the centre line survey and are now able to produce our own drawings of the cave.

## Acknowledgements

Ghar Parau Foundation <http://www.gharparau.org.uk/>

Mount Everest Foundation <https://www.mef.org.uk/>

Krnica Dive Centre, Croatia <https://www.krnica.com/>

Suex Scooters <https://www.suex.it/>

Halcyon Dive Systems <http://www.halcyon.net/>

Dive Proof <https://diveproof.com/>

## Appendices

### Example of Team packing List:

	A	B	C	D	E
1	<b>Agenda</b>	<b>Date</b>	<b>Details</b>	<b>Push Team</b>	<b>Support Team</b>
2	Travel	19th August 2021	Rich and Chris installed in Krnica, start doing gas	<b>To go into the cave on push days</b>	Tarp
3	Travel days	20st August 2021	LM MB land PUY 17:35 - get hire car and share	Chris Rich - CCR	Camp gear (basic)
4	Travel days	21st August 2021	FN lands in to PUY 14:00 - someone pick up Fred	Drysuit	Washing lines (sump 1 and 2)
5	Set up gear day (Krnica)	21st August 2021	Fills. Analyse. Reg up. Check regs for leaks. bag up. Pack in car.	Rocket tube of lime refill and ziplock bag - 1 x each	Camera gear
6	Travel to Fuzine	21st August (Sat)	Can drop bagged cylinders in the sump pool. Then pizza!	Fins each	
7	Day 1 Carry all to sump 2.	Sun 22nd August	Big carry day. Expect 6 hours.	Survey tube	
8	<b>Push Day 1</b>	Mon 23rd August	Chris and Rich. Aim at end of Ash's line in S4 and extend.	Survey underwater wetnotes and compass (Chris has)	
9	Day off	Tue 24th August		Line reel	
10	<b>Push Day 2</b>	Wed 25th August	Chris/Rich	Cave diving jewellery each + spare mask	
11	Day off	Thu 26th August		Primary torch each (not umbilical) 2 back ups plus helmet and light	
12	<b>Push Day 3</b>	Fri 27th August	Final push. Remove smaller, easier items from cave/ to sump 1 stash. Pack up camp.	Spare oxygen bottle	
13	Recover Gear Day 1	Sat 28th August	Big carry day. Expect 6 hours.	Bailouts regged up, in tackle bags	
14	Recover Gear/Spare Day 2	Sun 29th August	Stay at Fuzine night of 29th. Load van.	Emergency dry tube?	
15	Drive to airports	Mon 30th August	FN departs PUY 16:30, LM MB depart PUY 18:20	Emergency food in dry tube - to pack	
16				Spare spg	
17	<b>Christine</b>			3l Suit gas and reg	
18	Book ferry				
19	Insurance (car and personal)				
20	Covid card				
21	GHIC				
22	Passport				
23	<b>Notes to all from meeting</b>				
24	Drysuit failure for push teams is the major risk	All			
25	Support teams - turn all gas off at end of sump 1.	All			
26	Toolkit for S2 - pocket	Rich, Chris			
27	Spare caving battery to emergenc	Rich, Chris			
28	Insurance! Snow card etc?	All			
29					
30					
31					

## Web Links

Descent magazine [Centre Spread](#)  
Diver magazine [Article](#)  
The Master Cave [Film Link](#)  
Film Trailer [The Master Cave: Trailer](#)  
WetWellies [Blog](#)

## Distribution list

Ghar Parau Foundation  
Mount Everest Foundation  
Royal Geographical Society

## 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 than 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.

**Twinsset:** 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.