Underwater Trails: Balancing Tourism and Conservation in Freshwater Conditions

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Underwater Trails: Balancing Tourism and Conservation in Freshwater Conditions

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1. Introduction

1.1. Background of the Study

Underwater Trails (UT) are a mixture of recreation, education, and environmental stewardship, offering a unique opportunity to explore and appreciate the submerged world. Originating primarily in marine environments, UTs have garnered attention for their efficacy in fostering environmental awareness, promoting conservation efforts, and enhancing sustainable tourism practices. These designated underwater routes serve as immersive experiences, unveiling the intricacies of aquatic ecosystems, from vibrant underwater life to submerged cultural relics.

While UTs have flourished in marine settings, their application in freshwater environments remains relatively underexplored. Freshwater ecosystems, comprising lakes, rivers, and streams, are rich reservoirs of biodiversity and cultural heritage, yet they often lack the same level of visibility and protection as their marine counterparts. Therefore, an examination of UTs in freshwater conditions presents an opportunity to bridge this gap, amplifying awareness and conservation efforts within these vital habitats.

1.2. Importance of Balancing Tourism and Conservation in Freshwater Conditions

Freshwater ecosystems represent some of the most biodiverse and delicate environments on the planet. They provide vital services, including water purification, habitat for numerous species, and resources for human livelihoods. These ecosystems are particularly vulnerable to human activities such as tourism, which can lead to pollution, habitat degradation, and species disturbance. In Hungary, freshwater lakes serve not only as critical ecological zones but also as recreational spaces supporting diving tourism, making the balance between tourism and conservation a pressing concern.

Many of Hungary's freshwater dive sites attract enthusiasts due to their unique underwater landscapes, and ecological diversity and in some cases, historical artifacts. However, the human activities at these sites pose potential risks to the environment. Damage to aquatic vegetation, disruption of fish spawning areas, and pollution from waste, side products or littering are common consequences when tourism is not carefully managed. Unregulated or excessive diving in fragile ecosystems can lead to long-term environmental damage, reducing biodiversity and degrading the quality of dive sites. Such degradation ultimately diminishes the touristic value of these locations, creating a negative feedback loop that harms both the environment and the local economy.

On the other hand, tourism presents significant opportunities for conservation. Well-designed and responsibly managed diving activities can promote environmental awareness and contribute to the protection of underwater habitats. The creation of designated underwater trails is an example of how tourism can be structured to minimize its impact. By guiding divers along predetermined paths, underwater trails help reduce human interference with sensitive areas, while providing educational opportunities through interpretive signs and markers. Such initiatives not only protect the environment but also enhance the tourist experience by offering informative insights into the ecology and history of the dive site.

In Hungary, where freshwater diving is still an exotic activity in the tourism industry, the development of sustainable underwater trails offers a dual benefit. It can help establish Hungary as a responsible dive tourism destination while preserving its freshwater ecosystems for future generations. However, striking the right balance requires careful planning, guided by scientific research and collaboration with stakeholders, including environmental organizations, diving centers, and local communities. Without proper management, the ecological cost of tourism can outweigh its benefits.

This thesis aims to explore how Hungary's freshwater diving sites are managed today and would like to find the tools that help maximizing their touristic potential while minimizing harm to the ecosystem. Examining the interplay between tourism and conservation, this study seeks to identify strategies that can ensure sustainable diving practices in Hungary, allowing both the environment and the local tourism industry to thrive.

1.3. Objectives of the Research

After Identifying the most important elements of an underwater trail, the primary objectives of this research are the following:

- Assess the current state of freshwater diving sites in Hungary, with a focus on existing underwater trails.
- Analyse the correlation between visibility, depth, and substrate type at Hungarian dive sites and their impact on diving experiences.
- Develop and apply a method for calculating the touristic value of Hungarian dive sites.
- Identify the key factors influencing site selection and challenges faced by divers in Hungary through a survey of professional divers.
- Compare Hungarian dive sites and policies with international standards and best practices.

- Evaluate the balance between tourism development and conservation efforts in Hungarian freshwater diving locations.
- Propose recommendations for future underwater trails in Hungary
- Identify and propose new locations for future dive sites and trails in Hungary.

These objectives together form a comprehensive approach to understanding, evaluating, and potentially improving Hungary's freshwater diving sites, with a particular emphasis on their touristic potential. The research aims to provide both a current assessment of the situation and tools for future development and decision-making.

1.4. Structure of the Thesis

This thesis is structured to provide a comprehensive analysis of freshwater diving sites in Hungary, with a particular focus on underwater trails. The organization of the chapters reflects the systematic approach taken to address the research objectives and present the findings in a logical manner.

- **Introduction**: This chapter provides the background of the study, emphasizing the importance of balancing tourism and conservation in freshwater conditions. It outlines the research objectives and introduces the structure of the thesis.
- **Literature Review**: This section offers a theoretical foundation for the study. It defines underwater trails and their historical context, examines international case studies and best practices, and explores different types of underwater trails. Additionally, it summarizes diving policies worldwide and provides an overview of Hungarian diving law and its limitations.
- **Research Context and Area**: This chapter focuses on the geographical and ecological overview of Hungarian dive sites, highlighting the importance of freshwater diving in Hungary. It provides detailed descriptions of dive sites with existing underwater trails, specifically in Dorog and Gyékényes.

- **Research Methodology**: This section outlines the multi-faceted approach used in the study. It details the field research conducted, including diving and on-site measurements, and the reconstruction of existing diving trail maps. It also describes the interviews conducted with experts, the survey of Hungarian professional divers, correlation studies on visibility, depth, and substrate type, and the method developed for calculating touristic value.
- **Results and Findings**: This chapter presents the outcomes of the research, including the correlation between visibility, depth, and substrate type of dive sites, the potential touristic value of Hungarian dive sites, and comprehensive survey results. It also provides an inventory of dive sites, mapping their distance from the capital and popularity.
- **Recommendations**: Based on the findings, this chapter proposes recommendations for future underwater trails in Hungary. It suggests improvements for environmental and touristic value, discusses the educational potential of underwater signage, and proposes strategies for boosting dive tourism in Hungary. It also suggests recommendations on surface infrastructure based on the example of the Palationus Lake.
- **Conclusion**: The final chapter summarizes the key findings, highlights the study's contributions to tourism and conservation, and offers final thoughts on the future of diving trails in Hungary.

The thesis also includes appendices containing maps of diving trails, blueprints for proposed underwater signage, the survey questionnaire, transcriptions of expert interviews, and the methodology for touristic value calculation. A comprehensive list of references concludes the document.

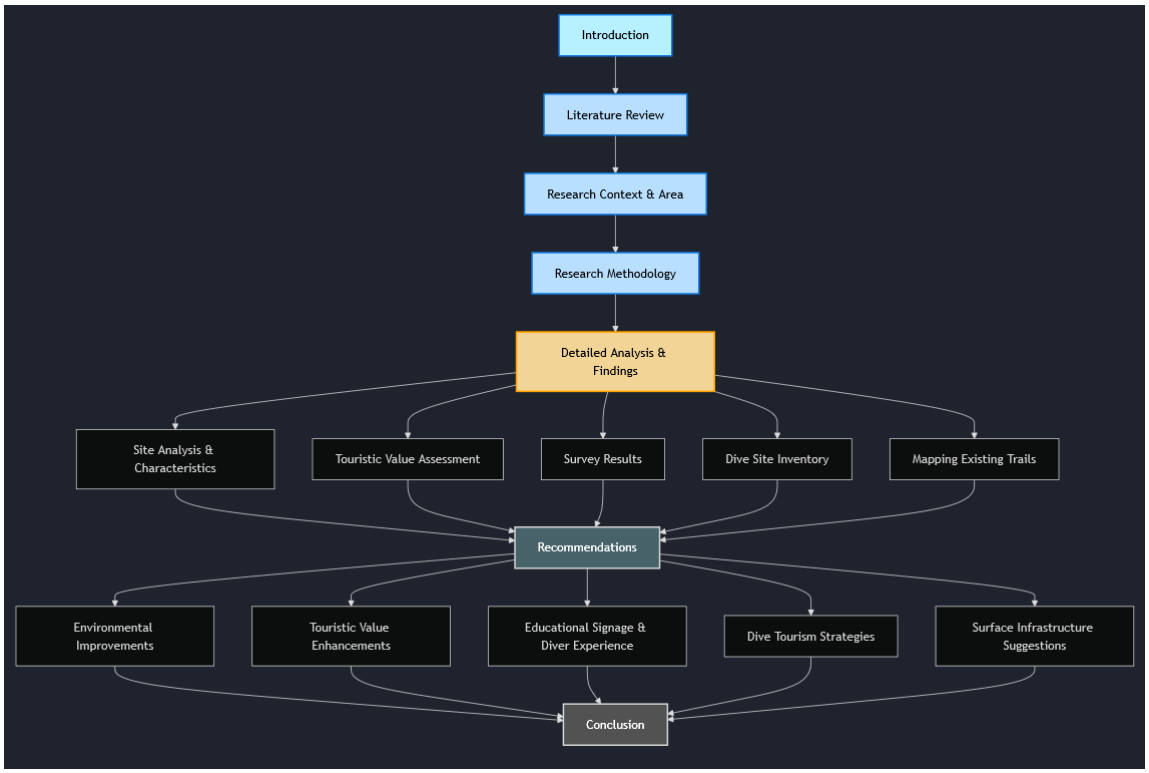


Fig 1: Flowchart of the Structure of the Thesis

This structure ensures a logical flow from the theoretical background through the empirical research to the final recommendations, addressing each of the research objectives systematically.

2. Literature Review

2.1. Underwater Trails: Definition and Historical Context

Underwater trails represent a dynamic intersection of marine exploration, education, and environmental stewardship (Baude et al., 2012). Originating from snorkeling, this leisure activity has evolved into a structured endeavor with a defined educational focus. The concept emerged as a response to the need for organized exploration of marine environments, transforming casual observation into a sport with the potential for significant environmental impact.

The evolution of underwater trails is evident in their development from ad hoc snorkeling experiences to meticulously planned educational excursions. Initially rooted in tropical regions like the British Virgin Islands (Baude et al., 2012) , snorkeling, or "sea-watching," offered individuals a means to appreciate underwater beauty without

the complexity of scuba diving equipment. However, it wasn't until the emergence of formalized underwater trails, such as those in the Mediterranean, that the activity became recognized as a tool for environmental education and conservation.

In the Mediterranean, particularly in countries like Spain and France, underwater trails gained traction as a means to protect marine environments while simultaneously engaging the public. Unlike traditional snorkeling, which often focused on leisure, underwater trails adopted an organized approach aimed at raising awareness about marine ecosystems and fostering behavioral change. This shift towards structured underwater experiences marked a significant milestone in the evolution of marine tourism, emphasizing the importance of sustainable practices and environmental education.

The contemporary definition of an underwater trail reflects this evolution, encompassing three essential elements: exploration in water, light equipment usage, and an educational focus designed to instigate behavioral change. As these trails continue to proliferate, their role in promoting sustainable tourism and environmental conservation becomes increasingly significant, setting a precedent for responsible marine recreation worldwide.

The evolution of underwater trails underscores the transition from casual snorkeling to organized, educational experiences aimed at promoting environmental awareness and sustainable practices. This evolution reflects a growing recognition of the importance of balancing tourism with conservation efforts in marine environments.

2.2. Types of Underwater Trails

The main factor when describing underwater trails is the depth, which determines the accessibility to the public by the type of diving required to get to the depth level where the area of interest is. Therefore, I arranged Underwater trails the trails into two main categories.

The first category is snorkelling trails which are developed in shallow waters and therefore there is no need for light diving equipment or skills to access such trail. As the name suggests the only equipment needed is snorkelling equipment, a mask and a

snorkel, but fins are also advised for better mobility. For this category no certifications are required, however some prior training and the ability to swim is really important.

The other category is diving trails where to access the trail visitors need to have the right training, certifications and diving equipment to access these trails. This category can be further divided into categories determined by the diving certificate categories. The depths accessible with only an Open Water Diver certificate are maximum 18 meters-, with Advanced Open Water Diver 30 meters-, with Deep diver 40 meters deep (NAUI, 2024). Any further depths are not reachable by regular compressed air tanks and require further technical diver training and equipment such as side tanks or rebreathers.

Name of the category		Depth
Snorkelling trail		0-10 m
Diving trail	Open Water	10-18 m
	Advanced	18-30 m
	Deep	30-40 m
	Technical	40m -

Fig 2: Diving trail categories by depth

To further understand the types of underwater trails one must understand the reasons to develop an underwater trail. There could be land-use and environmental conservation reasons, as the snorkelling activity already present is affecting the waterbody or the shorelines and there is a need to negate conflicts and negative effects and satisfy social needs. (Baude et al., 2012)

It is also a great tool to raise environmental awareness and educate the public, both in a professional and the recreational level.

It could be used as a promotion tool to increase the tourism activities in an area, by utilizing a natural resource – or to promote a heritage site, both in the sense of natural and historical heritage.

For these reasons, I choose to divide these sites into these following two categories.

2.2.1. Natural Underwater Trails

These trails are used to showcase the natural resources of an area, that could be of geological or biological origin. Usually developed and maintained by national parks and wildlife reserves. These trails are designed to allow divers to explore and appreciate the underwater environment while highlighting the natural beauty and resources of the area. These trails often lead divers through specific routes that showcase water life, coral reefs, and other underwater features such as underwater animals, providing a unique opportunity to observe and learn about the ecosystem. Additionally, these trails may incorporate educational elements to raise awareness about the importance of conservation and sustainable practices in preserving these natural resources. One of the examples is the Snorkel Trail Ramla tal-Mixquqa (Golden bay) in Malta set up as part of the MEDPAN NORTH project (ERA Malta, 2024).

Fig 3: Dog worm (Hermodice carunculata) photographed at the Ramla tal-Mixquqa (Golden bay) snorkel trail (own photo)

2.2.2. Underwater Heritage Trails

Underwater Heritage Trails are tools to help the understanding of historical events and give on-site information about objects or landmarks found in aquatic conditions (Maarleveld et al., 2013).

These trails allow visitors to explore and learn about historical shipwrecks and other underwater cultural heritage sites. These trails often feature a series of sites, such as the WWII Maritime Heritage Trail in the Pacific, which highlights Japanese and U.S. shipwrecks and assault vehicles from the Battle of Saipan (Warfare History Network, 2024). Another example is Adelaide's Underwater Heritage Trail in Australia, which explores four shipwrecks from the 19th century that represent a variety of vessels and materials used in sailing vessel construction during that era(South Australia Environment, 2024). Underwater Heritage trails often feature a series of sites, such as the Helsinki underwater park Kronprins Gustav Adolf, which is the first underwater park in the Baltic Sea and was built in 2000 at the wreck of a ship of the Swedish line (Finnish Heritage Agency, 2024). The park is free to enter and is open during the summer season, with a buoy for mooring a boat and information boards about the history of the ship and its structure. The goal of underwater parks is to help visitors recognise and interpret what they see, providing a unique opportunity to observe and learn about historical underwater sites. Inquiries about the park can be directed to the Finnish Heritage Agency researchers Päivi Pihlanjärvi and Minna Koivikko. These trails promote awareness and conservation of valuable cultural resources, while also offering a unique and interesting diving experience.

2.3. International Diving Trails: Case Studies and Best Practices

Underwater trails have emerged as a valuable tool for managing marine and freshwater environments, striking a balance between tourism promotion and conservation efforts all around the world. Several notable case studies and previous studies provide insights into the implementation and effectiveness of underwater trails. I have searched for the following trails and provided a brief description of them to better understand the usecase and best practises of each location. The underwater

trails can be cathegorized by the contents of the water medium surrounding each location. These two cathegories are Saltwater- and Freshwater Environments.

2.3.1 Diving Trails in Saltwater Environments

In this section I would like to showcase the following Diving Trails from Saltwater Environments:

- **Green Fins Initiative:** The Green Fins initiative focuses on promoting sustainable diving and snorkeling practices to protect coral reefs and marine life in various countries, including Thailand, Maldives, and Vietnam. By offering guidelines and support to dive operators, this program aims to reduce the ecological footprint of marine tourism activities (Greenfins, 2024).
- **Trunk Bay Underwater Snorkel Trail, U.S. Virgin Islands:** The Trunk Bay Underwater Snorkel Trail features a 650-foot self-guided trail with informative plaques highlighting the diverse coral and marine life in the area. By providing a designated area for snorkeling and educating visitors about the local ecosystem, this trail helps minimize environmental impacts and enhances the overall snorkeling experience (See St. John, 2024).
- **MEDPAN NORTH Project:** The MEDPAN NORTH project explored the use of underwater trails as a management tool for marine protected areas in the Western Mediterranean Basin. Through assessing tourism carrying capacity and monitoring impacts, this project aimed to enhance conservation efforts while promoting sustainable tourism practices (ERA Malta, 2024).
- **WWII Maritime Heritage Trail, U.S. Virgin Islands:** Divers can explore shipwrecks and submerged cultural resources from World War II along the WWII Maritime Heritage Trail in the U.S. Virgin Islands. This trail not only preserves historical artifacts but also offers a unique diving experience that contributes to the local tourism industry (ECU Maritime Heritage Program, 2024).
- **Helsinki Underwater Park Kronprins Gustav Adolf, Finland:** The underwater park in Helsinki features an underwater trail with interpretive signage to

educate visitors about the local marine environment and promote conservation awareness. By combining recreation with education, this trail enhances the visitor experience while fostering a sense of environmental stewardship. These case examples illustrate the diverse applications of underwater trails in marine and freshwater environments, showcasing their potential to support sustainable tourism practices, protect natural resources, and educate visitors about the importance of conservation (Project Baltacar, 2020).

2.3.2 Diving Trails in Freshwater Environments

In this section I would like to showcase the following Diving Trails from Freshwater Environments:

- **Lake Tahoe Underwater Trail, California:** Established in 2018, the Lake Tahoe Underwater Trail showcases the region's rich maritime history through submerged recreational watercraft and barges in Emerald Bay. This trail not only offers a unique diving experience but also serves as an educational platform for visitors to learn about the lake's history and ecosystem.

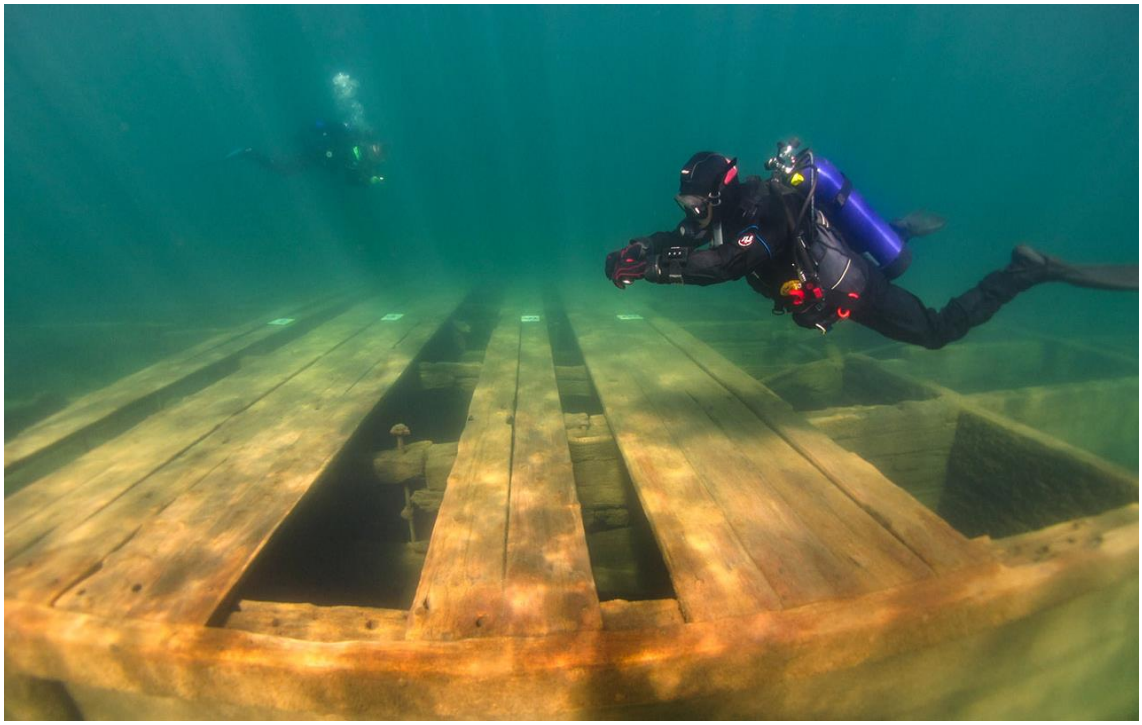


Fig 4 – A shipwreck on the underwater trail in Lake Tahoe (source: https://www.parks.ca.gov/?page_id=29931)

- **Blue Ridge Snorkel Trail:** The Blue Ridge Snorkel Trail in North Carolina offers a unique experience for snorkelers to explore the underwater world of mountain rivers (NC Fishes, 2024). This curated trail provides a series of snorkel sites where visitors can immerse themselves in crystal clear waters and discover a vibrant ecosystem filled with brilliantly colored fishes. The trail aims to offer an unforgettable experience for both seasoned snorkelers and beginners, showcasing the beauty of nature and providing educational opportunities about the aquatic life in the region. Additionally, the Blue Ridge Snorkel Trail is a free initiative, accessible to wildlife enthusiasts of all ages, making it a valuable outdoor adventure that promotes conservation awareness and appreciation for North Carolina's river ecosystems

2.4. Diving Policies Worldwide: A Summary of International Laws

Scuba diving is not a necessary mode of traversing when it comes to Underwater Trails, however, it is one of the possibilities, and from a touristic-economic perspective it is definitely a method to consider as it needs more facilities and equipment, therefore there is a monetary incentive to make scuba diving an option when it comes to these trails. So for this reason the legal background of scuba diving needs to be discussed.

Unfortunately, in Hungary there is very little governing legislation on diving and snorkeling, although there are aspects of the sport that should be regulated. I looked for international examples, as there is a lot of legislation in many parts of the world that sets the framework for diving. I would like to highlight one example from each continent to compare the regulations in as many different climates and cultures as possible.

- **Europe - Danish legislation**: Denmark has laid down the rules for diving in Act No 69 of 17 January 20124, "Consolidated act on diving operations and diving equipment, etc." (Danish Maritime Authority, 2014). The aim of the act is to ensure the safety of life and health of persons using diving equipment and persons rescued during diving operations, and to promote the safety and health conditions of persons carrying out diving operations. Diving participants must be qualified divers. Diving equipment designed for use while diving must

be designed, manufactured, installed, and maintained in such a way that the life and health of the user is adequately protected. If a diver is found by a court of law to be responsible for injuries to persons in connection with diving, the diver's diving certificate may be suspended for a specified period of not more than five years or permanently in aggravating circumstances.

- **Asia - Regulatory framework in Thailand:** Thailand's "Department of National Parks, Wildlife and Plant Conservation" aka the government agency called the "Department of National Parks, Wildlife and Plant Conservation" has the authority to regulate diving. This office is under the Ministry of Natural Resources and it falls under the Department of the Environment (The National Park, Wildlife and Plant Conservation Department, 2007). Divers must be suitably qualified and experienced for dive sites and have equipment in good condition.

  A buddy system is a compulsory element of safe diving, and the use of alcohol or mind-altering substances is strictly prohibited during dives, and diving under the influence of such substances is prohibited. Touching underwater surfaces, collecting and damaging living organisms and artefacts is prohibited. Feeding of organisms is prohibited. In addition, the leaving of waste and debris behind shall be avoided and reported immediately if it occurs for any reason. In the event of an emergency, all divers must follow emergency procedures and seek medical attention if necessary.
- **America - Mexican regulation:** According to the regulations of the Cabo Pulmo National Park in Mexico (CABOPULMO, 2024), visitors must pay a entrance fee and can only take part in guided tours. Visitors are required to follow local rules, not to wear snorkels or gloves, and not to touch sensitive surfaces and creatures. Diving is only possible if responsible ecotourism rules are followed, and the purpose of the dive is to study and observe wildlife and elements of cultural interest. The number of people taking part in the dive is also limited. Diving is prohibited in certain zones and only divers with appropriate training and experience are allowed in certain zones.The use of a dive buoy and dive flag is compulsory. It is forbidden to disturb, touch, follow or touch any living creature.

- **Africa - South African regulation:** Within the Addo Elephant National Park Protected Area in South Africa (Department of Environmental Affairs and Tourism, 2003), there are several rules that govern the safe and orderly framework for diving.

  All diving activities require a permit and diving is only allowed in designated dive sites. Divers must not disturb, damage or remove marine life. Spearfishing or the use of any fishing gear is prohibited. Diving is prohibited in certain zones where diving would disturb wildlife. The use of any gear for the collection of fish is prohibited. Any competition in the area must be authorised by the authorities. The introduction of domestic animals into the area is prohibited, so that they do not disturb or damage the wildlife.
- **Australia - Queensland regulation:** Queensland has set out the basic rules for diving in the Recreational Water Activities Safety Regulation 2011 (Queensland Government, 2023). Divers must be medically fit to dive and suitably qualified. It is compulsory to keep a dive logbook in which the diver must record, among other things, his/her name, the name of his/her partner, the date and the length and depth of the dive. This information can help diagnose medical problems and can also serve as evidence of any harmful activity.

2.5. Overview of Existing Policies for Underwater Trails

The legislation and legal background of Underwater Trails involve a complex interplay of international and national laws aimed at protecting underwater cultural heritage and environment. The protection of underwater cultural heritage is governed by various legal frameworks that emphasize preservation and proper management.

The UNESCO Convention on the Protection of the Underwater Cultural Heritage (UNESCO, 2001) plays a significant role in setting guidelines for the protection of underwater heritage, prohibiting its commercial exploitation and trade. This convention was accepted by Hungary in 2014 (INT 06). However, the CPUCH has faced challenges in gaining widespread ratification due to concerns about its preservationist approach and financial implications for states. In the European Union (EU), the legal framework for underwater trails and cultural heritage protection is

influenced by international agreements like the CPUCH and national laws that align with these principles. The EU emphasizes the importance of safeguarding underwater cultural heritage through regulations that prevent the commercial exploitation of such heritage and promote its preservation. The legal landscape surrounding underwater trails in the EU reflects a commitment to ethical considerations and the preservation of historical artifacts submerged underwater.

The protection of natural underwater trails is often governed by environmental and conservation laws at both national and international levels. These laws aim to safeguard marine ecosystems, biodiversity, and natural underwater landscapes from exploitation and degradation. In the context of natural underwater trails, regulations may vary depending on the specific location and the environmental significance of the area. These regulations typically address issues such as marine conservation, sustainable use of marine resources, and the preservation of underwater ecosystems. The legal frameworks for natural underwater trails often emphasize the importance of sustainable practices, ecosystem protection, and biodiversity conservation to maintain the ecological balance of underwater environments.

The legal landscape for underwater trails, whether focusing on cultural or natural heritage, reflects a commitment to preserving and managing underwater resources in a sustainable and responsible manner to ensure the long-term protection of these valuable underwater assets.

2.6. Overview of Hungarian Diving Law and Its Limitations

While Hungary does not have specific legislation governing underwater trails, several existing regulations and policies are relevant to their development and management:

- **Water management:** The Act on Water Management (1995. évi LVII. törvény a vízgazdálkodásról) regulates the use and protection of water resources, including springs and lakes.
- **Tourism development:** The National Tourism Development Strategy 2030 emphasizes sustainable tourism development and the promotion of unique natural attractions (Nemzeti Turizmusfejlesztési Stratégia, 2017).

- **Environmental impact assessment:** The Government Decree on Environmental Impact Assessment (314/2005. (XII. 25.) Korm. rendelet) requires assessment of potential environmental impacts for certain types of development projects.
- **Protected areas:** If the locations studied were to be designated as a protected area, additional regulations under the Act on Nature Conservation would apply.

These Regulations do not mention Diving Trails and as a relatively new tool it makes it hard and legally challenging to use them.

3. Research Context and Area

3.1. Hungarian Dive Sites: Geographical and Ecological Overview

Hungary, a landlocked country in Central Europe, may not be the first destination that comes to mind when considering diving locations. However, the country boasts a surprising array of diverse and intriguing dive sites that offer unique experiences for both novice and experienced divers. This section provides a comprehensive overview of Hungary's primary dive sites, their geographical characteristics, and the ecological systems that make them noteworthy.

The most prominent geographical features relevant to diving in Hungary include:

- **Natural Lakes:** Hungary boasts several natural lakes, with Lake Balaton being the most famous. These lakes offer diverse diving experiences, but they are not very deep and lack good visibility.
- **Quarry Lakes:** Hungary has numerous quarry lakes, formed as a result of mining activities. These man-made bodies of water, scattered throughout the country, have become popular diving destinations due to their often clear waters and unique underwater landscapes.
- **Thermal Lakes:** Hungary is renowned for its geothermal activity, resulting in several thermal lakes that offer year-round diving opportunities. The most famous of these is Lake Hévíz.
- **Underwater caves:** As Hungary is rich in natural caves it has ones that are filled with water and provide really great diving spots because of good visibility and

the high number of geological features that make them interesting. The downside is that cave diving is more on the dangerous side of the sports and requires specific training, therefore being more of a niche segment of diving.

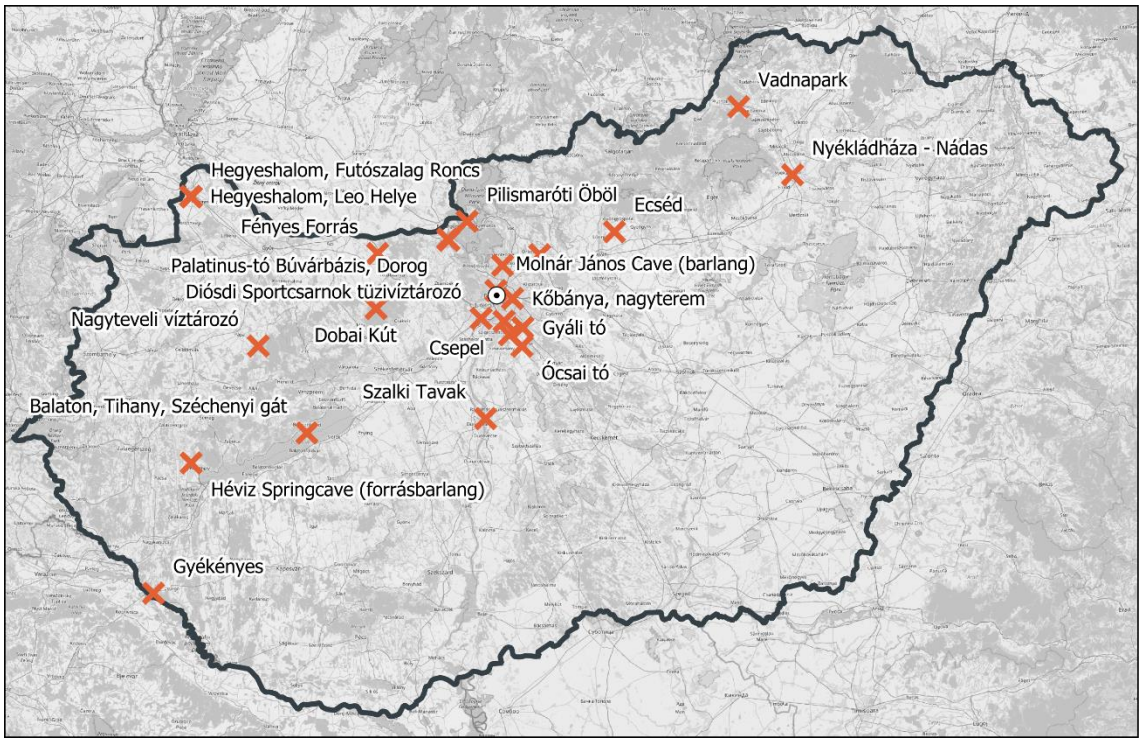


Fig 5: All the diving locations within Hungary

I have mapped 26 of the diving locations within Hungary (as shown on the map above) These locations can be generally found in the Northern Part of the country with most of the locations concentrated in the middle of Hungary.

3.2. Importance of Freshwater Diving in Hungary

Hungary's diving landscape is primarily dominated by its freshwater bodies, including natural water bodies such as lakes, rivers and underwater caves, and artificial ones such as flooded underwater buildings and quarry lakes. The country's geography is characterized by the Great Hungarian Plain in the east and the Transdanubian Mountains in the west. This varied terrain has given rise to a range of diving environments, each with its own distinct features and challenges. This study explores the standing water bodies as moving water is not very popular for diving in general and requires specific training.

As Hungary is land locked the main possibility of diving is freshwater environments, which are proved to be great locations for training, education and recreation. One of the main problems of freshwater diving is that touristically it is not as attractive as saltwater environments with coral reefs where the visual diversity of the habitats boost touristic interest. The other problem is the lack of underwater herritage sites which can be easily presented to the public by diving, as most of the lakes are shalow and the visibility is less then ideal.

For this reason underwater trails were developed already in two locations, Dorog and Gyékényes, two quarry lakes, where the elements of the diving trails combine historically interesting features such as vehicles artificially placed underwater with ecological features such as artificial breeding grounds or restored habitats.

3.4. Description of the Divesite Trails Studied:

In the following section I will showcase all the existing diving trails within hungary by looking at different sources. Some of the trails are really well documented while the others are unfortunatelly less mentioned in any sources.

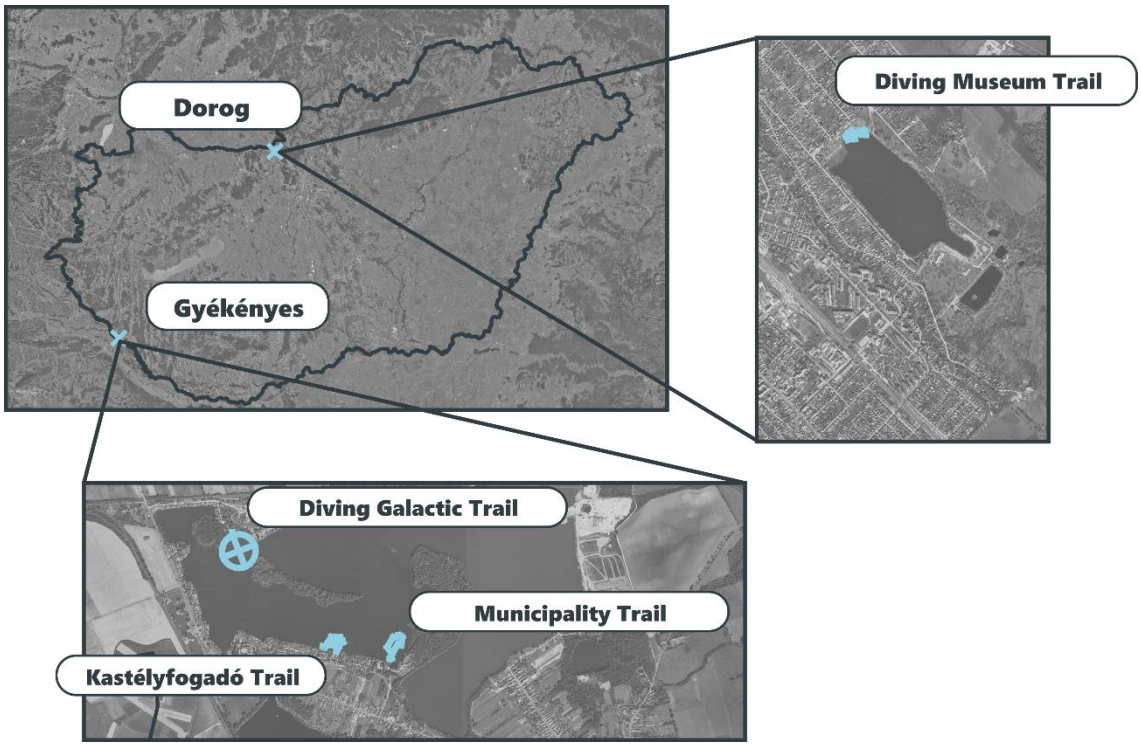


Fig 6: The locations of the existing diving trails within Hungary.

Generally speaking there are 4 existing trails, one of them is locatedat Dorog, the other three are in Gyékényes.

3.4.1. Dorog - The Diving Museum Trail

This trail in Hungary, Dorog, opened in 2006 called “Búvármúzem” that could be translated as “Diving Museum” is in a quarry lake. It is a unique underwater attraction located in the Palatinus Lake. Opened in spring 2006, it was the self-declared world's first underwater diving museum, offering visitors a chance to explore diving history in an immersive aquatic environment (Búvár Múzeum, 2009).

The museum's main exhibit is housed in a 60 cubic meter metal cage at the bottom of the lake, approximately 50-60 meters from the shore. Divers can access the museum using a rope system that starts from the shore-based diving base. The cage's interior walls display various historical diving artifacts, including old diving suits, breathing tubes, diving equipment, underwater lamps, informational panels, and explanatory texts. The exhibition showcases the history of diving from its early beginnings to modern times, as well as significant moments and equipment in underwater photography.

The collection features about 90 items, each over 20 years old and mostly non-functional. Over time, the cage and exhibits have become part of the lake's ecosystem, with algae, mollusks, and small fish making their homes among the displays. This integration allows visitors to observe the development and cycles of aquatic life alongside the historical artifacts.

The museum was created by Attila K. Kollár and Krisztián Kollár, using old equipment donated by local divers. The Spartacus SE club in Esztergom offered their diving base at Palatinus Lake as the site for the museum. The underwater cage was installed with the help of the FTSK DELFIN Light Diving Section, involving 10-12 divers over three days.

Nowadays the museum and the trail is operated by the local municipality.The concept of the Diving Museum Trail in Dorog remains an innovative approach to showcasing diving history. It combined educational aspects with the unique experience of underwater exploration, allowing divers to interact with historical artifacts in their natural element. This integration of history and nature created a distinctive learning

environment that highlighted both the technological progress of diving and the beauty of aquatic ecosystems.

3.4.2. Gyékényes - Municipality Trail

Unfortunately, the diving trails in Gyékényes are less documented and are made by enthusiasts with little to no permit and consultancy with the authorities or the owner of the lake. The municipality trail is close to the area owned by the municipality and that's where it got its name from. This was the first trail made in the Lake and one of it's main features is a "Barkas" minibus that is artificially thrown in to the quarry lake. The lake itself is uniquely clean and is home to world class sports event, sometimes including divig events.

3.4.3 Gyékényes Kastélyfogadó Trail

This trail is also not documented well but it is next to a local hotel called "kastélyfogadó" it is a small trail with smaller attractions and mainly used for training.

3.4.4 Gyékényes Diving Galactic Trail

The Diving Galactic Trail, inaugurated in 2024, represents the newest addition to the underwater attractions in Gyékényes. It is the biggest trail in Hungary as of today. This trail is a testament to the growing interest in underwater tourism and the commitment of local diving enthusiasts to create unique experiences for divers of all levels.

The project, still partially under development, was developed with the help of professionals, including the Hungarian Diving Association and the Pécs Diving Club. The concept for this trail emerged from a professional conference that brought together key stakeholders such as the Baranya County Water Management Directorate, MOHOSZ (National Federation of Hungarian Anglers), and the lake's operator.

One of the distinguishing features of the Diving Galactic Trail is its carefully planned infrastructure related to nature. Underwater or 'Sunken' Piers have been strategically placed to help Divers during training exercises. The trail covers depths

ranging from 3 to 12 meters, making it suitable for divers with varying levels of experience.

In an effort to support the local ecosystem, the trail incorporates artificial habitats designed specifically for pike-perch (zander) nesting. This integration of conservation efforts with recreational diving showcases a commitment to environmental stewardship and sustainable tourism. The trail offers a unique night diving experience as the diving centre also allows night dives.

Materials used in constructing the underwater attractions and structures include wood and metal, chosen for their durability in aquatic environments and minimal impact on the ecosystem. These materials also provide suitable surfaces for algae growth and shelter for various aquatic species, further enhancing the biodiversity of the site.

The development and management of the Diving Galactic Trail have been spearheaded by Jankó Vivien Melinda, who heads the Diving Galactic base, and Györkös Bence, the lead instructor. Their expertise and vision have been instrumental in creating a trail that balances recreational appeal with educational value and environmental consciousness.

One of the challenges faced by the trail's developers is the lack of a comprehensive legal framework governing such underwater attractions in Hungary. This situation has required close cooperation with local authorities and environmental agencies to ensure that the trail meets safety standards and environmental regulations.

Despite these challenges, the Diving Galactic Trail represents a significant step forward in underwater tourism in the region. It offers divers a chance to explore a carefully curated underwater environment, learn about aquatic ecosystems, and enjoy the unique beauty of Gyékényes' clear waters.

As the project continues to evolve, there are plans to add more features and educational elements to the trail. The team behind the Diving Galactic Trail is committed to ongoing improvements and expansions, with the goal of creating a world-class diving destination that combines adventure, education, and conservation.

The trail's potential success could serve as a model for future underwater attractions in Hungary and beyond, demonstrating how recreational diving can be harmoniously integrated with environmental protection and education. As it continues to develop, the Diving Galactic Trail is poised to become a premier destination for diving enthusiasts and a valuable asset for the local community of Gyékényes.

4. Research Methodology

This research employs a mixed-methods approach, combining quantitative and qualitative data collection techniques to comprehensively study underwater trails in Hungarian freshwater environments. The methodology was designed to address the research objectives through four main research streams: field research, expert interviews, professional diver surveys, and correlation studies.

The research methodology framework consists of several interconnected components:

- **Field Research:** Direct underwater observations and measurements, mapping and reconstruction of existing diving trails
- **Expert Consultation:** Structured interviews with diving professionals, Insights from water tourism experts
- **Quantitative Analysis:** Survey of 43 professional divers, Correlation studies of site characteristics, Development of touristic value calculation method
- **Data Integration and Analysis:** Synthesis of field observations, Analysis of survey responses, Development of recommendations

The methodology was designed to ensure triangulation of data sources, combining first-hand observations with expert knowledge and quantitative analysis. This multi-faceted approach allows for a comprehensive understanding of both the current state of underwater trails in Hungary and their potential for future development.

Each methodological component serves specific research objectives while complementing the others:

- Field research provides direct observational data and accurate site mapping

- Expert interviews offer insights into practical and theoretical aspects
- Survey data captures the current state of diving activities and diver preferences
- Correlation studies and touristic value calculations provide quantitative metrics for site evaluation

The following sections detail each methodological component and its implementation.

4.1. Field Research

To better map the existing diving trails mentioned above and produce the graphics for each location, different field research activities were done. These included dives along the trails and double checking the results with experienced divers ad local experts.

4.1.1. Diving and On-Site Measurements

To obtain accurate and reliable data during field research, a variety of tools and techniques were employed during the diving expeditions. These on-site measurements were crucial for documenting key environmental parameters and site characteristics.

A compass was used to ensure accurate navigation and orientation within the survey area, particularly when traversing different sections of the site. The compass was also essential for recording the direction of linear features, facilitating consistency across multiple dives.

An underwater notepad and pencil were used to record real-time observations and measurements. This method allowed for the immediate documentation of environmental features and specific site conditions, ensuring no critical details were lost during the dive. The notepad provided a waterproof solution for logging important data without the need to surface.

Fig 7 – Taking notes underwater during a field visit

Ropes and tape measures were utilized to establish fixed transect lines and to measure distances between key points of interest. The ropes were pulled over a distance and later measured, while the tape measures allowed for precise readings over shorter distances.

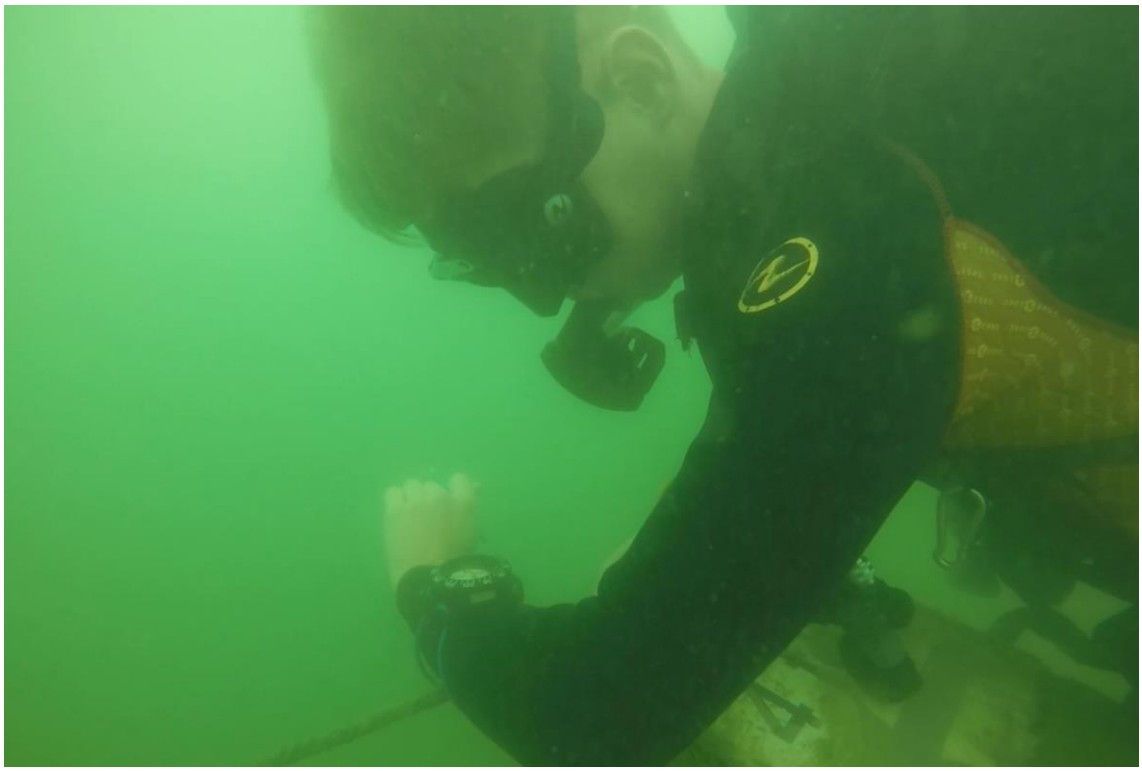


Fig 8 – Checking compass and measuring the ropes

In addition to these tools, kick cycles were employed as a supplementary method for estimating distances underwater. In general, it can be said that one kick cycle is around 1,5 m in length. This technique involved counting the number of kick cycles needed to traverse specific sections of the dive site, offering a quick and reliable measure for distances where the use of tape measures was impractical. Kick cycles were always recorded even during measuring something with ropes and tape measures as a backup data source.

To ensure accurate depth recordings, a depth gauge was used throughout the dives. This tool provided real-time information on the depth at various points during the survey, which was essential for mapping the vertical profile of the study area. The depth gauge readings were cross-referenced with other measurements to provide a comprehensive understanding of the site's topography.

The combination of these tools and techniques ensured that measurements were precise and consistent across all dives, contributing to the reliability of the data collected during the field research.

4.1.2. Map Reconstruction of Existing Diving Trails

Following the completion of the on-site measurements, the next step involved the reconstruction and digitalization of the diving trails. This process was essential for creating an accurate representation of the underwater landscape, particularly the spatial arrangement of objects, guiding ropes and landmarks encountered during the dives.

The map reconstruction process began with the data collected during the dives, specifically the distances between objects and their relative angles. Using the compass readings, the bearing of each object relative to a reference point was determined. These angular measurements provided a clear sense of directionality, while the distance measurements, obtained via tape measures and counting kick cycles, gave precise spatial positioning. By combining these two key elements—distance and bearing—a preliminary sketch of the dive site was created on an underwater notepad during the dives. These hand-drawn sketches were refined after the dive, with each object's position adjusted based on the compass readings and measured distances to create a more accurate representation of the underwater environment.

The manual drawings served as the foundation for the digital map. Using these sketches, the next stage involved transferring the information into a Geographic Information System (GIS), specifically QGIS, a powerful open-source software widely used for spatial analysis and map-making. The process of digitalization required careful attention to detail, as the hand-drawn maps had to be scaled and aligned correctly within the software. This involved the following steps:

- **Setting up the coordinate system:** QGIS requires an accurate coordinate system to ensure spatial consistency. For this project, a locally referenced grid system was established, based on the initial reference point defined during the dive. The compass bearings of objects were translated into angular coordinates, and the distance measurements were used to plot the positions of key objects within this grid.
- **Digitizing the hand-drawn sketches:** The rough sketches were scanned and imported into QGIS as a base layer. Using the software's drawing tools, the

major features and objects noted during the dive—such as objects of interest, wreckage, art installations, ecological features and other notable underwater structures—were traced digitally. Each object was placed according to its relative position, as determined by the distance and compass readings taken during the dive.

- **Creating spatial layers:** The digital map was divided into multiple layers to organize different elements of the dive site. For instance, distinct layers were created for the primary diving trail, the underwater structures. Each layer could then be manipulated independently, allowing for detailed analysis and adjustments as needed.
- **Ensuring map accuracy:** The initial digital version of the map was cross-referenced with the original hand-drawn notes to ensure accuracy. The use of QGIS also allowed for additional refinement, such as correcting minor discrepancies in distance or angle measurements. Any inconsistencies found in the digital version were corrected by revisiting the raw data from the dives.

Once the hand-drawn sketches had been fully digitalized, the final step was to enhance the map visually by adding cartographic elements such as a compass rose, scale bars, and labels for the most significant features of the dive site. These additions were crucial for interpreting the map easily and for presenting the data in a professional format. The use of QGIS's symbology tools allowed for different object types to be symbolized with distinct shapes and colours, improving clarity and making the map more user-friendly.

The resulting digital map provided a comprehensive, accurate visual representation of the dive sites, including the precise locations of underwater features in relation to each other. This map served not only as a navigational aid for future dives but also as a critical tool for analysing the spatial relationships between biological and geological features within the site. The map could also be updated with new data collected in subsequent surveys, ensuring it remained a dynamic and evolving tool for ongoing research.

4.2. Interviews Conducted

To gain deeper insights into the challenges and opportunities of balancing tourism and conservation in freshwater environments, particularly in the context of underwater trails, two expert interviews were conducted. These interviews provided valuable perspectives from both practical diving experience and broader water tourism expertise.

The first interview was with Károly Halász, a PADI Master Scuba Diver Trainer with extensive experience in both international and Hungarian diving locations. His insights focused on the practical aspects of diving, the current state of Hungarian dive sites, and potential improvements for underwater attractions.

The second interview featured Dr. Tamás Bardócz, a water tourism expert with a broad international perspective on freshwater ecosystem management and sustainable tourism practices. His expertise provided a more comprehensive view of the ecological, economic, and policy aspects of freshwater tourism and conservation.

These interviews complemented each other well, offering a blend of hands-on diving knowledge and broader ecosystem management principles. They provided crucial information on the current state of freshwater diving in Hungary, potential areas for development, and strategies for balancing tourism growth with environmental conservation.

The following subsections present detailed summaries of each interview, highlighting key points and recommendations that inform the broader objectives of this research on underwater trails in freshwater conditions.

4.2.1. Interview with Károly Halász, PADI Master Scuba Diver Trainer

Károly Halász, born on March 7, 1965, is a PADI Master Scuba Diver Trainer with over 8,000 dives to his credit. The interview, conducted in Hungarian, provided valuable insights into underwater trails, diving sites, and the potential for diving tourism in Hungary.

Halász shared his experience with international underwater attractions, such as the Christ statue in John Pennekamp National Park, Florida, which is a replica of the "Il

Cristo degli Abissi" statue in Italy. He also mentioned purposely sunken shipwrecks in Malta that serve as artificial reefs with ecological functions. He explained that these structures are quickly populated by fish and corals due to the iron content, which is scarce in seawater but essential for marine life.

In freshwater environments, Halász cited examples of sunken objects in Hungarian dive sites, such as a helicopter and a boat in Dorog, and a Lada car in Lake Omsk. These structures serve as hiding places for predatory fish like pike-perch and pike.

Regarding the development of diving sites, Halász described coral rehabilitation efforts he observed in Raja Ampat, Indonesia, and the Great Barrier Reef, Australia. He also participates in annual cleaning efforts at dive sites in Hungary and Egypt.

Halász has dived in most notable Hungarian locations, including thermal caves like Rákóczi Cave, Aggtelek, Hévíz, Tapolca, and the Budapest caves such as Molnár János Cave. He also mentioned several quarry lakes as popular diving spots in Hungary.

According to Halász, Hungarian dive sites are suitable for most diver training and certification programs, except for deep diving due to depth limitations. Cave diving certifications are also restricted to specific locations.

To improve Hungarian dive sites, Halász emphasized the importance of water clarity. He suggested dredging, chemical treatments, and ecological filtration systems to enhance visibility. He also recommended adding more artificial structures like wrecks to increase the sites' appeal, provided they are properly prepared and environmentally safe.

Halász advised site operators to create eco-friendly dive bases with clean changing facilities, heating for winter diving, and amenities like saunas, toilets, and showers. He also highlighted the business potential in equipment rental and air tank filling services.

Finally, Halász suggested that Hungary has untapped potential for organizing dive tours, particularly to locations with good visibility, warm water (even in winter), and rich flora and fauna.

4.2.2. Interview with Dr. Tamás Bardócz, Water Tourism Expert

Dr. Tamás Bardócz, a renowned water tourism expert, provided extensive insights into the delicate balance between tourism and conservation in freshwater environments. His expertise spans across various countries and ecosystems, offering a comprehensive perspective on the challenges and opportunities in this field.

Tourism and Conservation in Freshwater Environments: Dr. Bardócz emphasized that preservation should be an integral part of tourism promotion in freshwater ecosystems. He stated, "The main touristic value of these ecosystems can be lost without preservation; therefore, the whole destination management and marketing should be based on protection of environmental values." He cited angling tourism on Lake Tisza as a successful example where tourism and conservation coexist, highlighting the importance of limitations on vessel sizes, engine power, and the implementation of local angling rules and restricted areas.

Regarding the long-term impacts of freshwater tourism on local biodiversity, Dr. Bardócz pointed out the complexity of freshwater ecosystems and their various habitats. He noted that littoral ecosystems of water plants and nesting birds are affected by visitor disturbance, while underwater ecosystems can be degraded by increased traffic from large motorboats, jet skis, and wakeboard vessels. To mitigate these impacts, he suggested limiting visitors and regulating transport methods within the ecosystem, as well as educating visitors about protection measures.

Dr. Bardócz observed that some countries focus more on rules and restrictions (like Hungary), while others emphasize training visitors and local people. He believes the latter approach can have a more significant impact. He also stressed the potential of social media as an excellent channel for the tourism industry to educate the public about freshwater conservation.

Importance of Freshwater Ecosystems: The expert elaborated on the critical ecological roles of freshwater ecosystems globally, referencing the Common International Classification of Ecosystem Services (CICES). He explained that these ecosystems provide various services, including provisioning (e.g., fish), regulating and maintenance (carbon sequestration), and cultural (tourism, landscape) services.

Dr. Bardócz identified climate change as the biggest threat to freshwater ecosystems, particularly in the Carpathian Basin. He warned of potential consequences such as loss of surface waters, increasing eutrophication, and succession of remaining freshwaters. He also highlighted the importance of wetland habitats for migrating bird species and how their reduction could lead to population degradation.

Challenges and Opportunities in Freshwater Tourism: Uncontrolled tourism was identified as a significant challenge for freshwater ecosystems. Dr. Bardócz pointed out that engine-powered water sports, buildings, and constructions in the littoral region pose the biggest threats. He emphasized the need for sustainable transport of visitors and education of both visitors and locals to leverage freshwater resources for sustainable tourism while protecting sensitive environments.

Regarding infrastructure, Dr. Bardócz stressed its role in defining the main flows of visitors to avoid mass use of sensitive areas. He sees great potential in eco-friendly activities like diving in freshwater environments but emphasized the need for strict control of visitor numbers and activities.

Conservation Strategies in Freshwater Environments: Dr. Bardócz praised the Natura 2000 protection approach as particularly successful, noting that it allows economic activities aligned with conservation goals. He stressed the importance of involving local communities in tourism and integrating it into the local economy, with decision-making at the local level.

The expert discussed the role of technology in monitoring and conserving freshwater ecosystems, mentioning the use of real-time water quality data, big data analysis, and satellite image analysis for planning and implementing conservation measures. He also highlighted the often-overlooked risk posed by invasive species, especially in a changing climate.

Advice for Policymakers and Future Directions: Dr. Bardócz advised policymakers to always involve local communities in the planning and management of tourism. He suggested better utilization of citizen science methods in freshwater ecosystems, particularly for surveying underwater habitats and fish populations through diving experiences.

In conclusion, Dr. Bardócz's insights underscore the complex interplay between tourism and conservation in freshwater environments. His expertise highlights the need for a balanced approach that considers ecological preservation, sustainable tourism practices, and community involvement. As freshwater ecosystems face increasing pressures from climate change and human activities, the strategies and perspectives shared by Dr. Bardócz offer valuable guidance for policymakers, conservationists, and tourism operators alike.

4.3. Survey of Hungarian Professional Divers

This study employs a mixed-methods approach, combining quantitative survey data with qualitative analysis to evaluate freshwater diving locations in Hungary. The research design aims to provide a comprehensive understanding of the current state of freshwater diving in Hungary, diver preferences, and the potential for sustainable tourism development through underwater trails.

I conducted a comprehensive survey of 43 professional divers in Hungary to get a better understanding of the divesites within the country. The survey aimed to gather information on popular diving spots, factors influencing site selection, overall diving experiences, frequency of dives, and challenges encountered while diving in Hungary.

4.3.1. Survey Sample (43 Professional Divers)

The survey was conducted by asking certified divers who have experience in the divesites withing Hungary. Divers whose experience and expertise are relevant are hard to reach as it is a very specific group of people with no online or in person groups tying them together specifically. Luckily an opportunity was presented for me as an event was organised in Budapest where I got to meet local divers, went around and asked them the survey questions, digitally recording the results. All of the participants were certified divers from Hungary, aged between 16 and 70.

	Which of the following freshwater diving spots in Hungary have you visited? (Multiple choice, select all that apply)		Which of these factors is most important when choosing a freshwater diving spot in Hungary?		How would you rate the overall diving experience at Hungary's freshwater diving locations? (Scale 1–5)		How often do you dive in freshwater locations in Hungary? (Single choice)		Which of the following challenges have you encountered while diving in Hungary? (Select all that apply)	
Diver 17	Balaton, Tihany, Széchenyi gát	X	Water clarity		1 (Very Poor)		Weekly		Poor visibility	X
	Csepel		Depth	X	2 (Poor)		Monthly		Accessibility issues	
	Diósdi Sportcsarnok tüziviztározó		Underwater attractions	X	3 (Average)		A few times per year	X	Lack of safety infrastructure	X
	Dobai Kút		Accessibility		4 (Good)	X	Once a year or less		Limited underwater attractions	X
	Dunaharaszti, Vizisí Tó		Cost		5 (Excellent)				Temperature	X
	Ecséd		Safety	X					Other	
	Erdőkertesi Octopus Horgász- és Búvártó		Other							
	Fényes Forrás	X								
	Gyáli tó									
	Gyékényes	X								
	Hegyeshalom, Futószalag Roncs	X								
	Hegyeshalom, Leo Helye	X								
	Héviz Springcave (forrásbarlang)	X								
	Kőbánya, kerti kút	X								
	Kőbánya, nagyterem	X								
	Lupa, Budakalász	X								
	Molnár János Cave (barlang)	X								
	Nagyteveli víztározó									
	Nyékládháza - Nádas									
	Ócsai tó									
	Öböl Beach Búvárcentrum	X								
	Palatinus-tó Búvárbázis, Dorog	X								
	Palatinus-tó, Dorog Kis öböl	X								
	Pilismaróti Öböl									
	Szalki Tavak									
	Vadnapark	X								

Fig 9: Example of some of the results recorded in a digital table, by hand, on location.

4.3.2. Survey Questions and Focus Areas

The survey was designed to gather comprehensive data on the experiences, preferences, and challenges faced by divers in Hungary's freshwater environments. The questions were carefully crafted to address several key areas of interest, providing valuable insights into the current state of freshwater diving in the country and potential areas for improvement. The survey consisted of five main questions, each focusing on a specific aspect of freshwater diving in Hungary:

- **Diving Location Preferences**: The first question presented respondents with a list of 26 freshwater diving spots across Hungary, including popular locations such as Fényes-forrás, Dorog, Gyékényes, Hévíz Springcave, and the Molnár János Cave. Participants were asked to select all the locations they had visited. This multiple-choice question aimed to identify the most popular diving spots in Hungary, gauge the diversity of locations visited by divers and highlight potential underutilized or lesser-known diving sites
- **Factors Influencing Site Selection:** The second question focused on the key factors that influence divers' choices when selecting a freshwater diving spot in Hungary. Respondents were asked to choose the most important factor from the following options: Water clarity, Depth, Underwater attractions, Accessibility, Cost, Safety, or Other. This question aimed to understand the primary motivations behind site selection, identify areas of potential

improvement for dive site operators and guide future development of underwater trails and attractions

- **Overall Diving Experience Rating:** Participants were asked to rate their overall diving experience at Hungary's freshwater locations on a scale of 1 (Very Poor) to 5 (Excellent). This question sought to assess the general satisfaction level of divers, provide a benchmark for comparing Hungary's freshwater diving experiences with international standards and identify potential gaps between expectations and reality in the diving experience
- **Frequency of Diving:** The fourth question asked about the frequency of diving in freshwater locations in Hungary, with options ranging from weekly to once a year or less. This question aimed to understand the level of engagement and commitment of divers to freshwater locations identify potential correlations between diving frequency and overall satisfaction and gauge the potential for growth in the freshwater diving market
- **Challenges Encountered:** The final question addressed the challenges faced by divers in Hungary's freshwater environments. Respondents could select multiple options from a list:,Poor visibility,Accessibility issues, Lack of safety infrastructure, Limited underwater attractions, Temperature, or Other. This question was designed to identify the most pressing issues facing freshwater diving in Hungary, prioritize areas for improvement in dive site management and development and understand the potential barriers to growth in the freshwater diving sector

The Focus Areas of the survey questions were carefully crafted to address several key focus areas relevant to the study of underwater trails and the balance between tourism and conservation in freshwater conditions:

- **Popularity and Distribution of Diving Sites:** By asking about visited locations, the survey aimed to map out the current landscape of freshwater diving in Hungary, identifying hotspots and potential areas for development.
- **Diver Preferences and Motivations:** Understanding the factors that influence site selection provides valuable insights for both conservation efforts and tourism development strategies.

- **Quality of Experience:** The overall rating question helps gauge the current state of freshwater diving experiences in Hungary and identifies areas for improvement.
- **Engagement and Market Potential:** The frequency of diving question provides information on the current level of engagement and the potential for growth in the freshwater diving market.
- **Barriers and Challenges:** Identifying the main challenges faced by divers helps prioritize areas for improvement and guides future development and conservation efforts.

The survey provides a comprehensive overview of the current state of freshwater diving in Hungary, offering valuable data to inform the development of underwater trails and sustainable diving tourism practices.

4.4. Correlation Studies: Visibility, Depth, and Substrate Type at Dive Sites

Based on data gathered from divecenter.hu and several personal records I have made a database of each divesite in hungary, containing their visibility data, the maximum depth recorded and the substrate type of the site. This data was later used for analysis to determine the correlation between these factors.

4.5. Touristic Value Calculation Method Developed

In the following, I would like to describe the methodology developed for the touristic value of each divesite. To calculate the tourism potential, I have prepared an evaluation table (Table 1), grouped according to the four most important aspects of dive sites, based on the conclusions of the chapter on Diving in rehabilitated mining lakes. These are Visibility, Depth, Area, Object of Interest.

Point value:	1	2	3	4	5
Visibility	0m	0-4m	4-10m	10-25m	Above 25m
Depth	0m	0-5m	5-10m	10-25m	More than 25m
Area	0ha	0-1ha	1-10ha	over 100 ha	10-100ha
Object of interest	None	Wall	Wreck, (frame only)	Wreck, (cargo)	Wreck, (toral wreck)

Table 1: Assessment of dive sites

The distribution of the range of the scores is the range of visibility that can be entered on divecenter.hu. For depth, the defining criterion was obtained by grouping the depths shown on the map of lakes in the section on diving in lakes. The score of the area is given by the time of immersion of the water bodies, the highest score is not given to the value with the largest area, but to the one smaller than it, since this is the scale that is still suitable for diving and not too large for the creation of currents and wave formation. I classified the score of the object of interest based on the complexity of the object, its tourism potential, the more complex the object of interest the higher the score the site gets. In the table, wrecks are mainly included because this type of object is the most significant in Hungary.

The rounded average of these assessment criteria gives the expected rating of the dive site by divers. Its formula is:

$$\frac{(\text{Visibility score} + \text{Depth score} + \text{Area score} + \text{Object of Interest score})}{4}$$

There are, however, other aspects that are not fixed or diver-dependent that can influence the dive rating, but these are not part of the most important aspects I have identified because they are not subjective enough for analysis. These may include weather conditions such as heavy rainfall, drought, low or high temperatures, and the diver's mood, attitude and emotional attachment to the site.

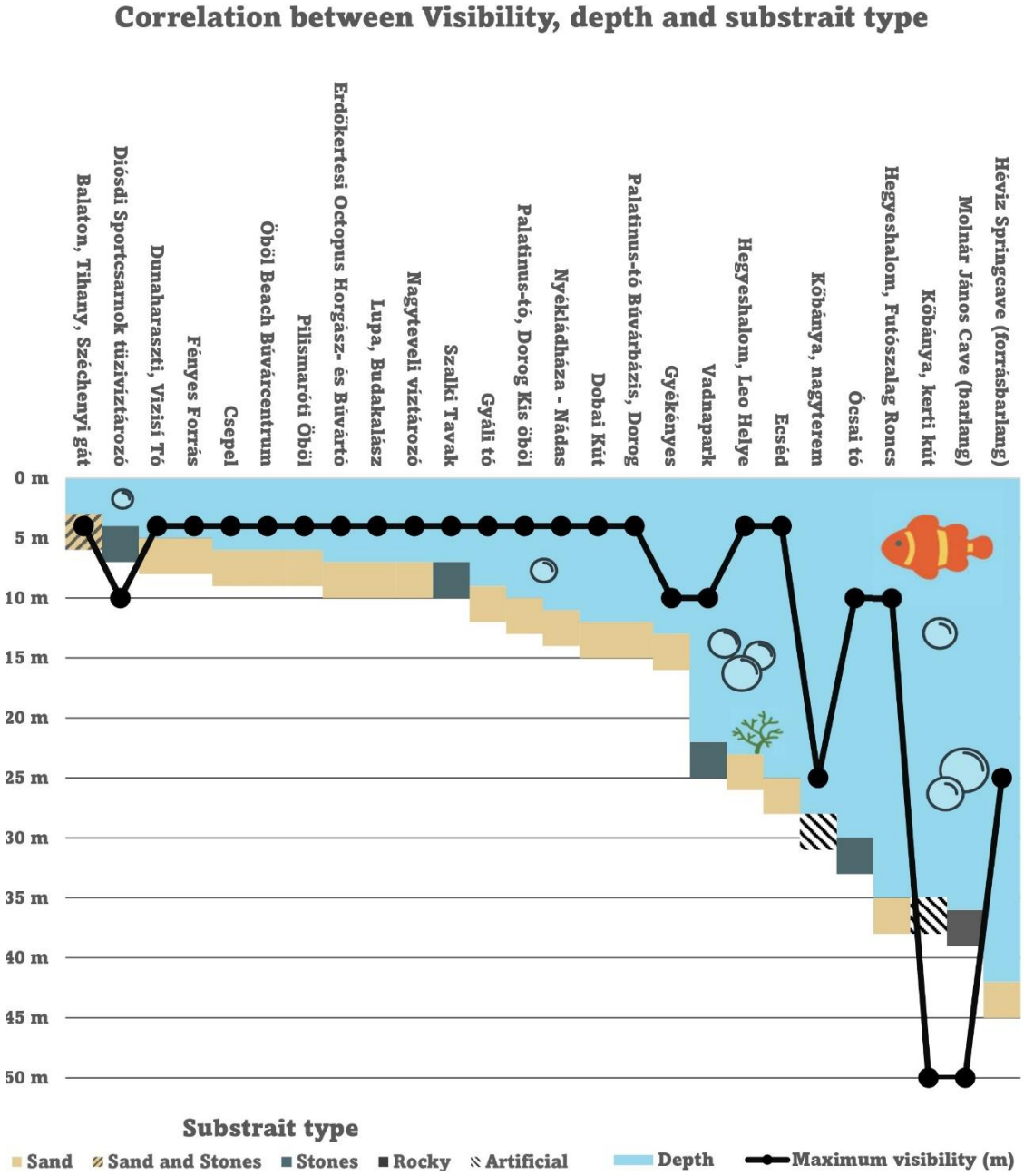
5. Results and Findings

5.1. Correlation between Visibility, Depth, and Substrate Type of Dive Sites

The dive sites have been analysed and classified in several ways. I tried to determine the environmental conditions of good visibility, to determine the potential tourist value of the dive sites and compared this with the diver ratings.

I classified the dive sites in Hungary according to visibility and evaluated how depth and bottom type affect visibility (Fig 10) based on the reviews given on divecenter.hu for each site. The evaluation clearly shows that sandy, shallow water bodies have

poorer visibility, while deeper, rocky or artificial bottomed dive sites have better



visibility.

Fig 10: Evolution of visibility as a function of depth and substrate type

In freshwater ecosystems, visibility is one of the key factors influencing the quality of the diving experience and the health of underwater ecosystems. Understanding the interplay between visibility, depth, and substrate type can help manage underwater trails in a way that both promotes tourism and preserves the ecological integrity of freshwater dive sites.

This shows the correlation between visibility, depth, and substrate type across several dive sites, offering valuable insights into the conditions at each site (Fig 10). The substrate types are categorized into sand, sand and stones, stones, rocky, and artificial. The graph also shows the maximum visibility at each site (in meters) as well as the depth of each site, with data presented for depths ranging from the surface down to 50 meters.

Substrate types appear to influence visibility significantly. In sites dominated by sandy substrates, visibility tends to fluctuate more noticeably, especially in shallower waters. This is particularly evident in sites like *Öböl Beach búvárcentrum* and *Fényes forrás*, where visibility dips to approximately 5 meters. These substrates tend to stir up particles more easily, reducing visibility, particularly in areas where tourism or water movement is higher.

In contrast, sites with a more stable rocky or stone substrate, such a*s Molnár János Cave*, tend to have better and more consistent visibility. These substrates are less prone to particle suspension, thus improving water clarity. Interestingly, artificial substrates, as found in *Kőbánya*, also show relatively higher visibility at certain depths, indicating that human-made structures can sometimes stabilize water conditions.

Depth also plays a pivotal role in visibility, as expected. At most dive sites, visibility improves with increased depth up to a certain point before declining again. For instance, sites like *Gyékényes* and *Hévíz Spring Cave* show increased visibility around the 10-meter depth mark, with a noticeable drop as divers approach deeper layers. This may be due to the clearer water at mid-depths, where sediment disturbance is minimal but light penetration is still adequate.

However, some sites, like *Fényes forrás* and *Dorog*, show a marked decline in visibility even at shallow depths, suggesting local environmental factors such as water turbidity or seasonal changes affecting these areas.

Current trails established in Hungary are in sandy locations and after discussion with experts it is clear why, the infrastructure for trails such as fixing points are easier to install in sandy bottoms. However, from these correlations, it is evident that both the substrate type and depth should be carefully considered when designing or managing freshwater underwater trails. Therefore I suggest that based on this data Future trails

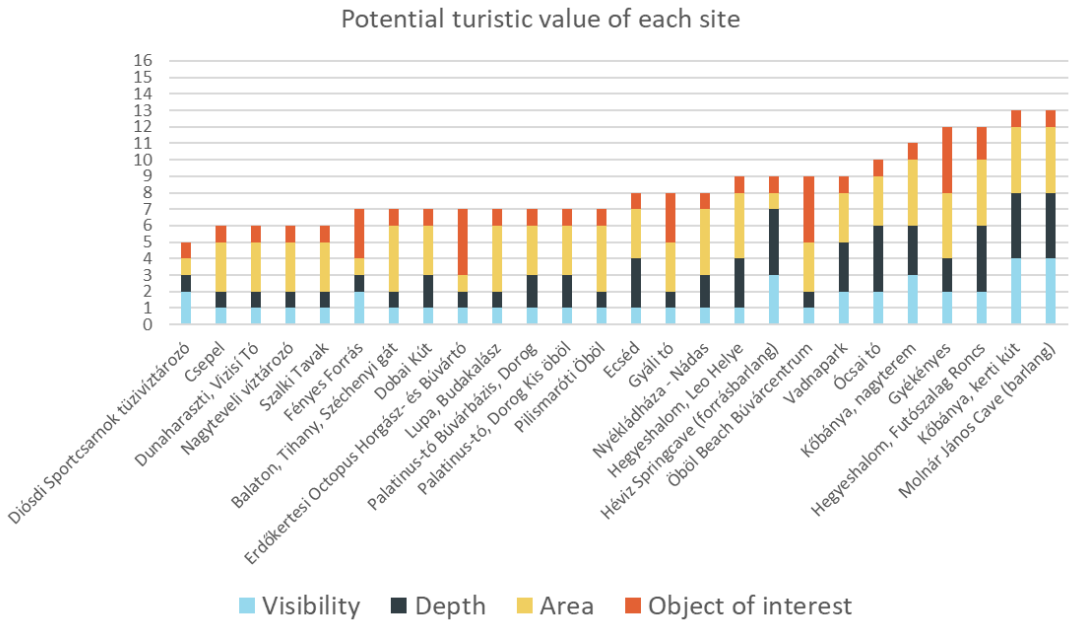
planned in areas with rocky or stone-based substrates are likely to offer better visibility, improving the experience for divers and minimizing human impact on the environment on the long run. Additionally, adjusting the depth of trails to optimize visibility — targeting mid-depths where water clarity is highest — can further enhance the ecological and tourism value of these sites.

By understanding and applying these correlations between depth, visibility, and substrate type, underwater trail systems can be tailored to balance tourism with conservation goals, ensuring that the natural beauty and ecological health of freshwater dive sites are preserved for future generations.

5.2. Potential Touristic Value of Hungarian Dive Sites

5.2.1. Touristic Value Calculation Results for each site

After calculating the potential touristic value for each site, the results are the following:



The sites with the highest potential touristic value tend to have a balanced combination of these factors. The highest-ranked site, *Molnár János Cave (barlang),* scores highly across all four criteria, particularly in terms of object of interest and area.

This makes it a prime location for tourism due to its distinctive cave system, which attracts both divers and explorers.

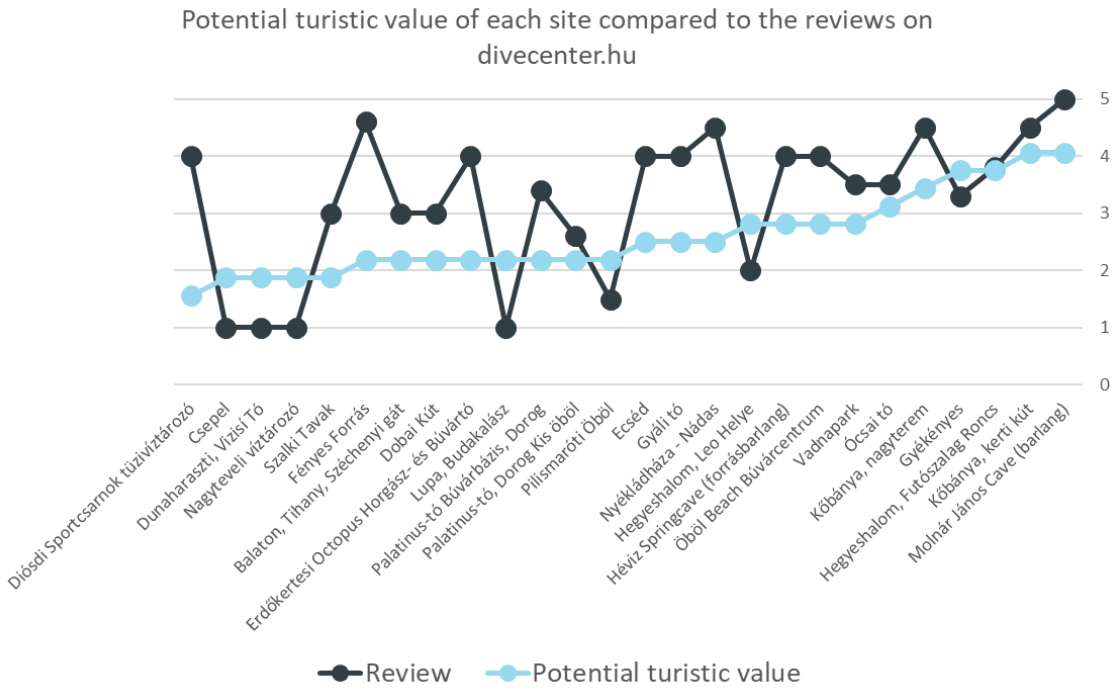
Similarly, *Kőbánya, Kert Kút*, and Hegyeshalom also exhibit strong touristic potential, largely driven by their high scores in the object of interest category. These sites offer unique experiences that set them apart from others, with rich historical or natural features that enhance their attractiveness.

In contrast, sites like *Diósdi Sportcsarnok* have lower overall scores. While these sites may still hold interest, they lack significant depth, visibility, or distinguishing features that would appeal to a broader range of tourists. These locations are therefore more niche in terms of their touristic value.

Overall, the ranking of the sites reflects a combination of environmental and cultural factors that influence their attractiveness for tourists. Sites with a strong presence of natural beauty, unique underwater or historical features, and ample space for activities generally rank higher on the scale, offering greater touristic value.

5.2.2. Comparison with User Reviews from divecenter.hu

It can be said that the results of the assessment method I have developed are in line with the divers' assessments, but there are other subjective factors (e.g. emotional attachment to the site) that influence the diver's assessment.Furthermore, the divesites are not developed fully to their potential, therefore getting negative or positive results based on how presenteble are their values. For this reason, there are differences between the results of the calculation and the divers' assessment:



With this graph it can be clearly seen that not only the personal experience determines the final result, but the touristic potential of the sites is not reached.

5.3. Survey Results

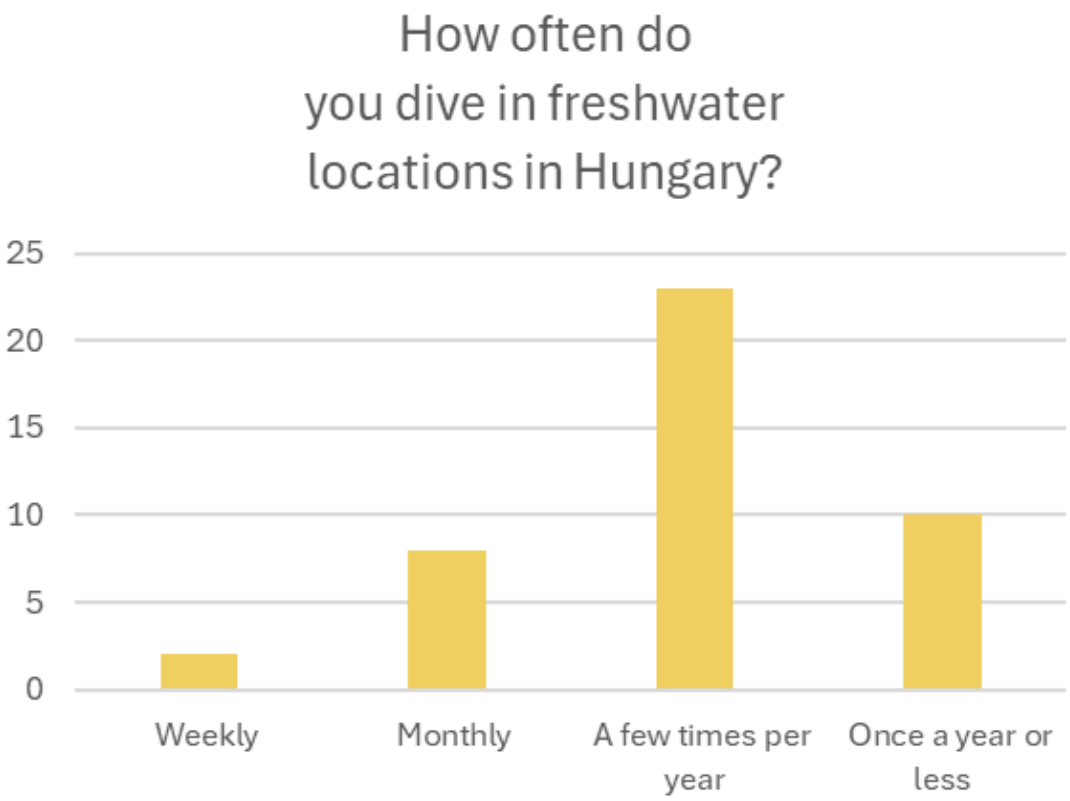
In this section I would like to present the findings of the survey described in the Research Methodology section.

5.3.1. Frequency of Diving in Freshwater Locations in Hungary

The survey revealed that most divers visit freshwater locations in Hungary a few times per year:

- Weekly: 2 responses
- Monthly: 8 responses
- A few times per year: 23 responses

- Once a year or less: 10 responses

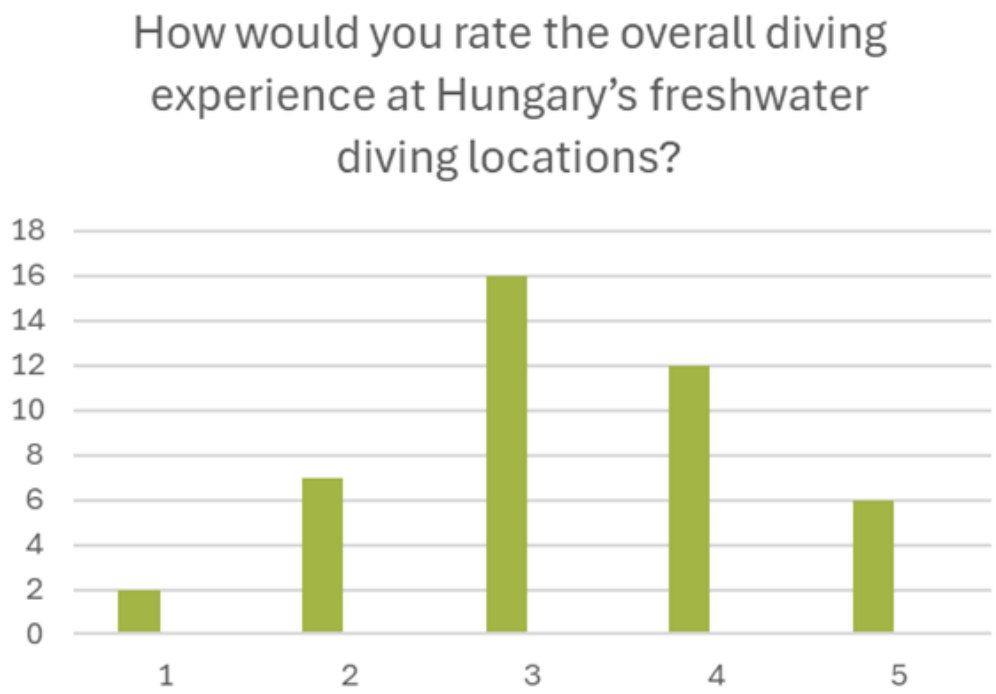


This frequency suggests that there is a consistent interest in freshwater diving among professionals, but there may be potential to increase visitation rates through improved attractions like underwater trails.

5.3.2. Overall Diving Experience Ratings

The survey asked respondents to rate their overall diving experience at Hungary's freshwater locations on a scale of 1 (Very Poor) to 5 (Excellent). The results were as follows:

- 1 (Very Poor): 2 responses
- 2 (Poor): 7 responses
- 3 (Average): 16 responses
- 4 (Good): 12 responses
- 5 (Excellent): 6 responses

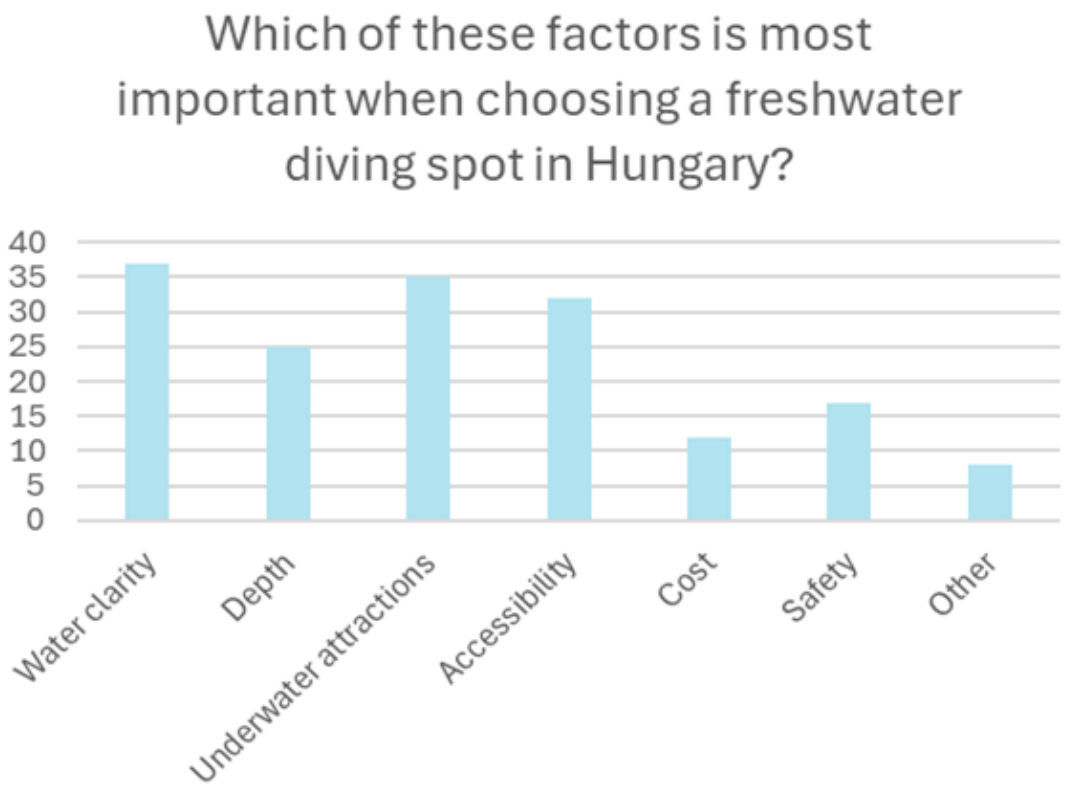


The average rating was 3.30, indicating that there is room for improvement in the overall diving experience at Hungarian freshwater sites. This suggests that the development of an underwater trail could potentially enhance the diving experience and attract more visitors.

5.3.3. Factors Influencing Site Selection

When choosing a freshwater diving spot in Hungary, divers considered the following factors most important:

1. Water clarity (37 responses)
2. Underwater attractions (35 responses)
3. Accessibility (32 responses)
4. Depth (25 responses)
5. Safety (17 responses)
6. Cost (12 responses)
7. Other (8 responses)



The high importance placed on water clarity and underwater attractions aligns well with the potential development of an underwater trail, as these factors are crucial for creating an engaging and educational experience.

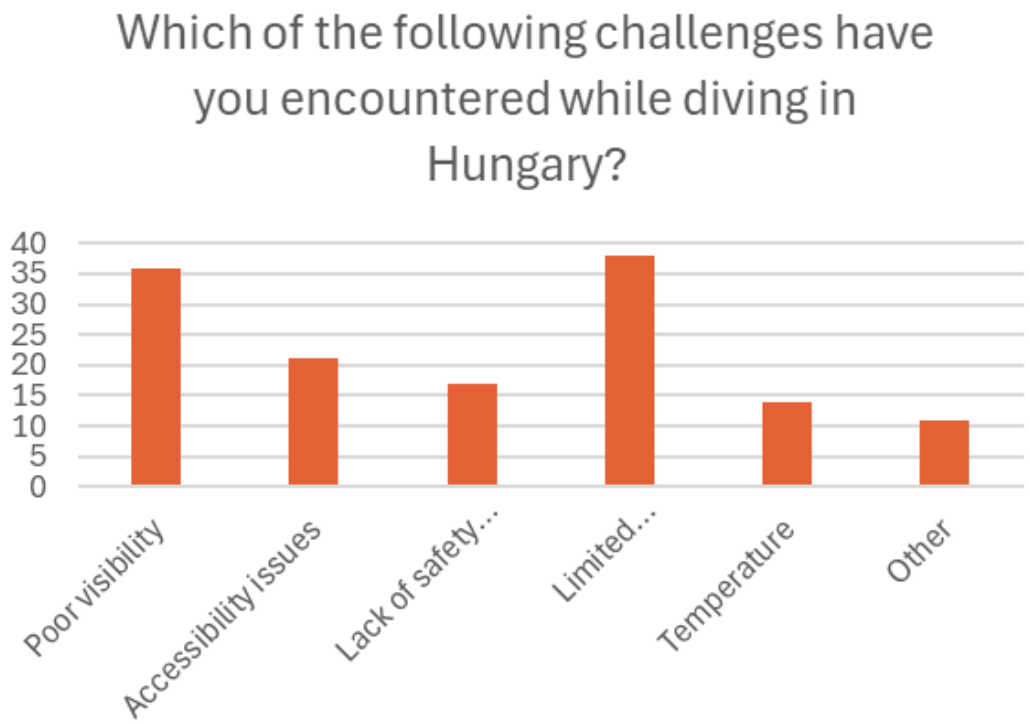
It is important to note here that the in the “other” sections divers mentioned temperature, divesite complexity, and wildlife.

5.3.4. Challenges Encountered by Divers

The main challenges reported by divers in Hungary were:

1. Limited underwater attractions (38 responses)
2. Poor visibility (36 responses)
3. Accessibility issues (21 responses)
4. Lack of safety infrastructure (17 responses)
5. Temperature (14 responses)

6. Other (11 responses)



The high number of responses indicating limited underwater attractions further supports the potential benefits of developing an underwater trail to enhance the diving experience. In the “other” section divers named among others the currents, the lack of overall infrastructure and differences compared to saltwater environments.

5.3.5. Most Popular Dive Locations Based on Survey

The survey results provided valuable insights into the preferences and experiences of professional divers in Hungary. Here's a detailed analysis of the findings:

The survey revealed that the most visited freshwater diving spots in Hungary are:

1. Fényes Forrás (39 visitors)
2. Molnár János Cave (37 visitors)
3. Palatinus-tó Búvárbázis, Dorog (37 visitors)
4. Gyékényes (30 visitors)

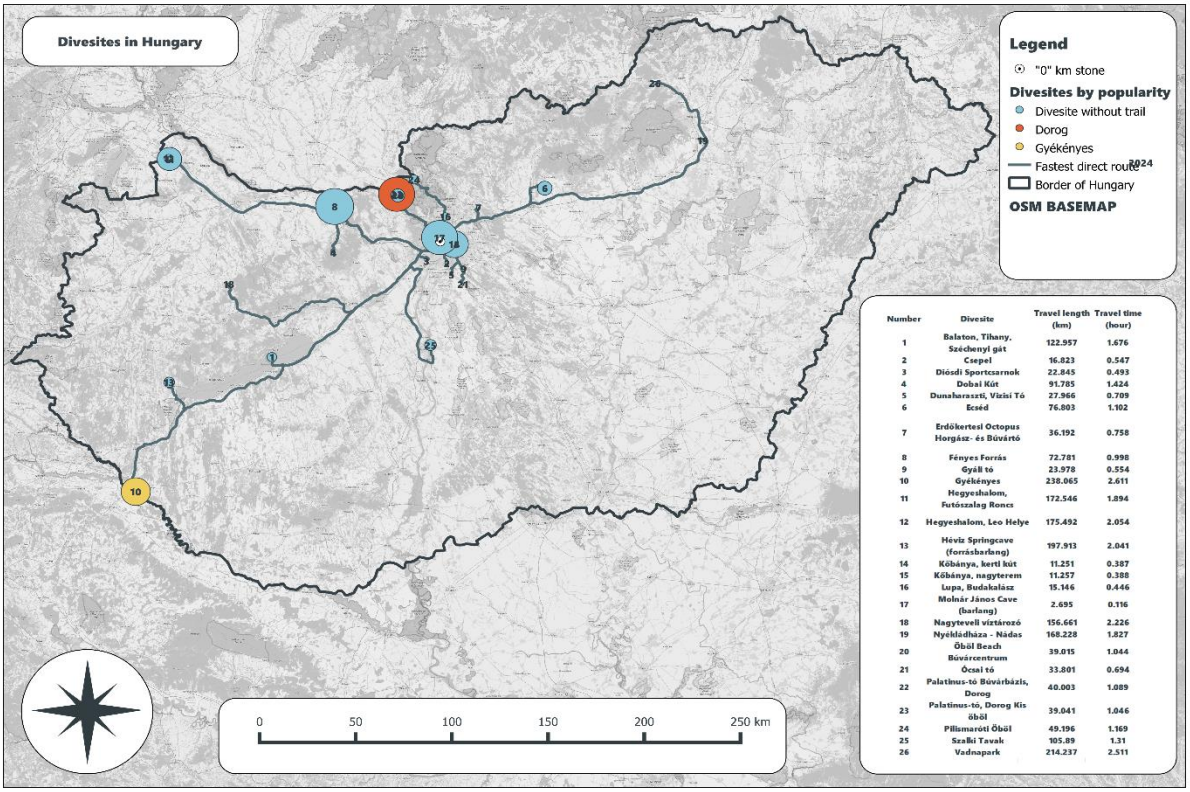
5. Kőbánya, kerti kút (29 visitors)

No. of visitors	Location
10	Balaton, Tihany, Széchenyi gát
4	Csepel
2	Diósdi Sportcsarnok tüzivíztározó
4	Dobai Kút
2	Dunaharaszti, Vizisí Tó
15	Ecséd
4	Erdőkertesi Octopus Horgász- és Búvártó
39	Fényes Forrás
6	Gyáli tó
30	Gyékényes
25	Hegyeshalom, Futószalag Roncs
9	Hegyeshalom, Leo Helye
11	Héviz Springcave (forrásbarlang)
29	Kőbánya, kerti kút
16	Kőbánya, nagyterem
8	Lupa, Budakalász
37	Molnár János Cave (barlang)
2	Nagyteveli víztározó
4	Nyékládháza - Nádas
10	Ócsai tó
2	Öböl Beach Búvárcentrum
37	Palatinus-tó Búvárbázis, Dorog
14	Palatinus-tó, Dorog Kis öböl
10	Pilismaróti Öböl
12	Szalki Tavak
4	Vadnapark

Fényes Forrás emerged as the most popular location, with 90.7% of respondents having visited the site. This high visitation rate suggests that Fényes Forrás is well-known among the diving community and has features that attract divers consistently.

5.4. Dive Site Inventory: Distance from Capital and Popularity

After the interviews conducted I have decided to make a distance map from Budapest for each divesite. The reason behind this is that the most tourists arrive from Budapest to the diving locations. The following map showcases the most important travelling routes of current toursists to each location.



Number	Divesite	Travel length (km)	Travel time (hour)
1	Balaton, Tihany, Széchenyi gát	122.957	1.676
2	Csepel	16.823	0.547
3	Diósdi Sportcsarnok	22.845	0.493
4	Dobai Kút	91.785	1.424
5	Dunaharaszti, Vízisi Tó	27.966	0.709
6	Ecséd	76.803	1.102
7	Erdőkertesi Octopus Horgász- és Búvártó	36.192	0.758
8	Fényes Forrás	72.781	0.998
9	Gyáli tó	23.978	0.554
10	Gyékényes	238.065	2.611
11	Hegyeshalom, Futószalag Roncs	172.546	1.894
12	Hegyeshalom, Leo Helye	175.492	2.054
13	Hévíz Springcave (forrásbarlang)	197.913	2.041
14	Kőbánya, kertl kút	11.251	0.387
15	Kőbánya, nagyterem	11.257	0.388
16	Lupa, Budakalász	15.146	0.446
17	Molnár János Cave (barlang)	2.695	0.116
18	Nagyteveli víztározó	156.661	2.226
19	Nyéládháza - Nádas	168.228	1.827
20	Óbál Beach Búvárcentrum	39.015	1.044
21	Öcsai tó	33.801	0.694
22	Palatinus-tó Búvárbázis, Dorog	40.003	1.089
23	Palatinus-tó, Dorog Kis öböl	39.041	1.046
24	Pilismaróti Öbül	49.196	1.169
25	Szabi Tavak	105.89	1.31
26	Vadnapark	214.237	2.511

Fig 11: Divesites and their distance from Budapest

After determining the location of the dive sites, I calculated their shortest distance by road from the "0" milestone. I considered the car approach because, given the amount, weight and size of the diving equipment required, the car is the most practical vehicle for accessing the sites. This shows that the dive sites are mainly located around Budapest. Of the dive sites, 16 are located in the Transdanubian region.

The closest dive site is the Molnár János cave, which is located about 3 km from the "0" milestone. The furthest dive site is Gyékényes, close to the Croatian-Hungarian border, 238 km away. In terms of time, these are also the extremes, with the Molnár János cave being about 7.2 minutes' travel time and Gyékényes 157 minutes. A disproportionate amount of travel time is associated with the reservoir at Nagyteveli,

where the 157 km distance is 134 minutes compared to Nyékládháza, 168 km away, where the travel time is 110 minutes.

Out of these divesites, only two has existing underwater trails developed, one of them is Palatinus lake in Dorog, which has a diving trail called „Búvármúzeum” and the other lake is in Gyékényes, called „Gyékényesi kotró” which has 3 underwater trails installed as of 2024.

5.5. Mapping Existing Underwater Trails: Dorog and Gyékényes

In this section I mapped the existing diving trails in Hungary to better understand and inventorize the items and solutions used when making such an underwater feature.

5.5.1. Dorog - The Diving Museum Trail

The Diving Museum Trail at Dorog offers an engaging underwater route designed for divers to explore various submerged objects, many of which are tied to the region’s historical and recreational diving activities. I have mapped the trail and made a map that could help the divers in the future to better understand the trail and it’s actual size and orientation (Fig 12). The trail, marked by a sequence of buoys and underwater structures, begins at the pier and offers an intriguing combination of natural features, artificial landmarks, and historical relics.

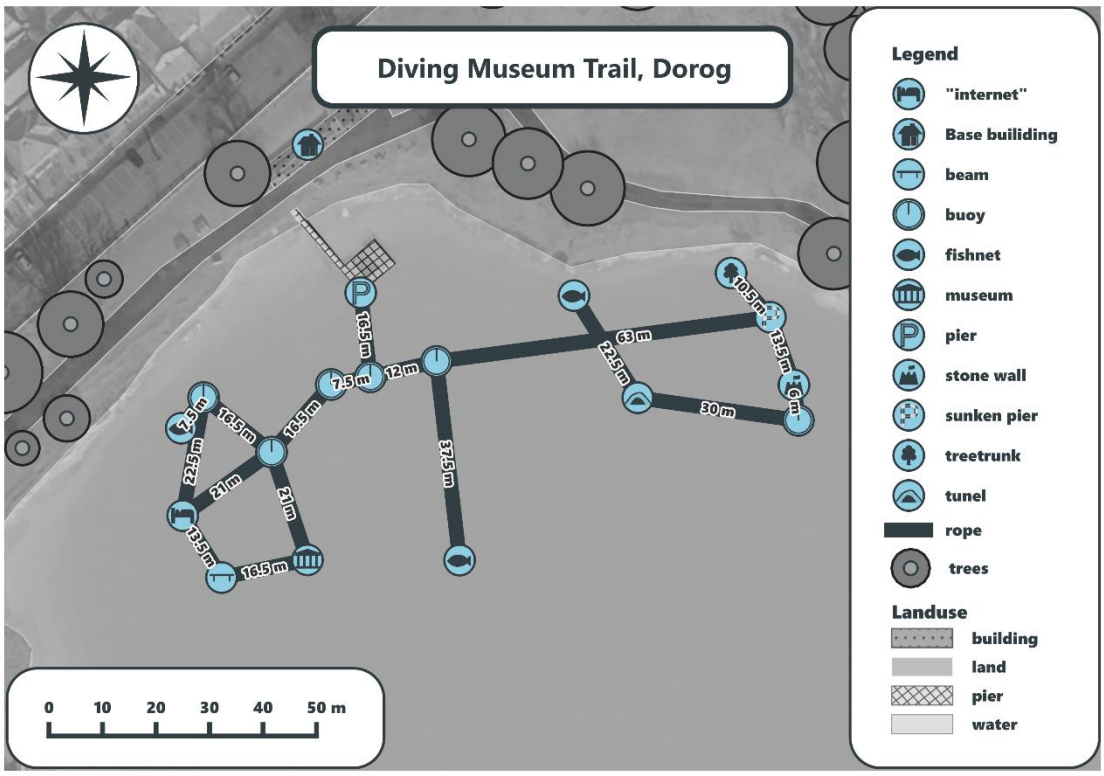


Fig 12 – The trail at Dorog.

The trail starts at the pier, a prominent above-water structure that serves as both an entry and orientation point for divers. From here, divers descend and follow a rope leading to the first buoy, marking the beginning of their underwater journey.

From the pier, a 16.5-meter rope connects directly to a buoy, which serves as the initial reference for divers to navigate the rest of the trail. This buoy is the critical junction of the trail, from which two main sections diverge.

Section 1: is the Western Route. It begins from the initial buoy and spans a distance of 7.5 meters, leading to a secondary buoy. From here, the trail extends 22.5 meters to another marked point, known as the "internet," which is a submerged contemporary art piece, made of a desk, chair and an old computer, which had its components removed that could potentially damage the environment. Continuing from this point, the rope stretches a further 13.5 meters to connect to a historical beam, serving as another feature of the dive. The beam is linked to the museum site itself, a significant point on the trail, which is connected by a 16.5-meter rope. It was originally found in

the river Danube and moved to it’s current location to be showcased to divers.The museum structure, which is a metal cage, acts as both a physical endpoint and an informational centre, where divers can observe artifacts and displays representative of the diving history.

Section 2 I the eastern route. It starts from the initial buoy connected to the pier. Divers can follow the rope for 16.5 meters to reach a third buoy, and from there, the trail offers several interconnected segments. A 21-meter line extends from the buoy to another landmark buoy. At this point, divers can take a 16.5-meter rope leading to the beam structure encountered on the western route. Divers also encounter a series of interconnected points, such as the "fishnet" structure, a 37.5-meter line leading to the "sunken pier," and another rope that leads to a buoy located near a stone wall. The stone wall represents another significant underwater relic, linked to the "tree trunk," which is located further along the trail and offers an intriguing glimpse of natural underwater elements. A final rope of 30 meters connects the stone wall to the sunken pier and an adjacent tunnel, which adds an adventurous element to this section of the trail.

Notable Structures and Landmarks Throughout the trail, divers can observe an array of significant objects, including:

- Fishnets: Representing both historical fishing activities and their use in diving-related activities.
- Sunken Pier: A Pier submerged and integrated into the underwater environment, primarily used for training.
- Beam and Museum Structure: The museum is a key feature, offering insight into the region's diving heritage, while the beam is another structural element contributing to the uniqueness of the site.
- Tunnel: A submerged passage that adds complexity and interest to the exploration.
- Stone Wall and Tree Trunk: These natural elements contribute to the scenic beauty of the underwater landscape, offering contrast to the man-made artifacts.

The trail is interconnected through a well-designed system of ropes, ensuring safe and structured navigation between various points of interest. The distances between objects vary, with ropes as short as 6 meters (between the buoy and the stone wall) and as long as 63 meters (from the buoy to the sunken pier), providing ample opportunity for divers to explore at a comfortable pace while being continuously guided by the markers.

5.5.2. Gyékényes - Municipality Trail

The Gyékényes - Municipality Underwater Trail is a recreational diving route offers an engaging experience for divers. Set in the calm waters of Gyékényes, a well-known diving site located in a former quarry, this trail allows participants to explore a mix of man-made landmarks. The trail is accessible to divers of varying skill levels, making it a popular attraction for both beginner and seasoned divers seeking to discover hidden underwater treasures.

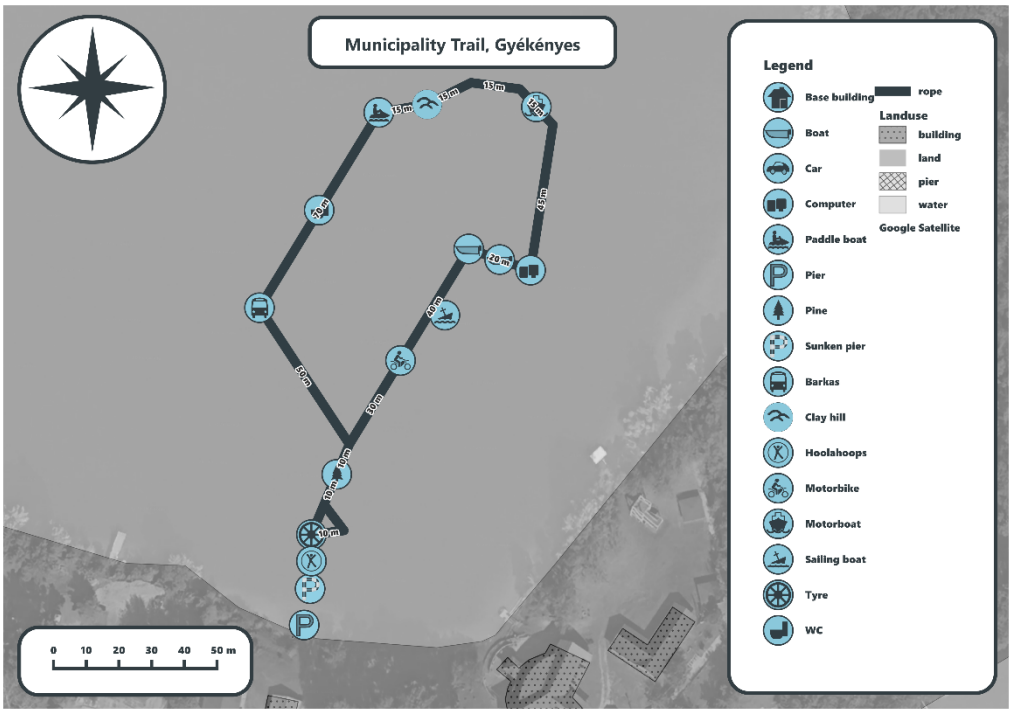


Fig 13 Gyékényes Municipality Trail

The trail begins at a pier, serving as the primary entry point. From here, divers immediately encounter the first object on the trail: a sunken pier, located just a short distance away. This initial segment is connected by a sturdy guide rope, ensuring divers

have a clear path to follow. From the sunken pier, divers swim along the guide rope for approximately 17 meters until they reach a tyre, a playful relic submerged near the surface.

Continuing along the same line, divers are led to a set of hula hoops, adding a whimsical touch to the trail, before reaching one of the first significant natural landmarks, a pine tree. This tree is located about 18 meters from the hula hoops and serves as a visual transition between the man-made objects and the more natural features of the trail.

At this point, the trail splits into two distinct sections. The primary route continues towards the Barkas, an iconic submerged vehicle, 50 meters from the pine tree. The Barkas is a key highlight of the trail, providing a captivating historical artifact for divers to explore. From here, divers can choose to follow a path leading to a series of sunken structures, including a WC and a paddle boat, connected by a guide rope 70 meters in length. Both of these objects offer unique photo opportunities, especially the paddle boat, which evokes a sense of nostalgia as it rests peacefully on the lakebed.

The trail then proceeds to Clay Hill, a natural feature that adds geological interest to the otherwise human-made points along the route. The smooth transition from the paddle boat to Clay Hill, spaced only 15 meters apart, allows divers to observe the interplay between the natural and man-made worlds. From Clay Hill, the trail concludes with the final few objects, including a motorboat, which lies near the computer and a small boat cluster. These objects are spaced out in quick succession, offering a rewarding end to this section of the trail, ending at a sunken motorboat.

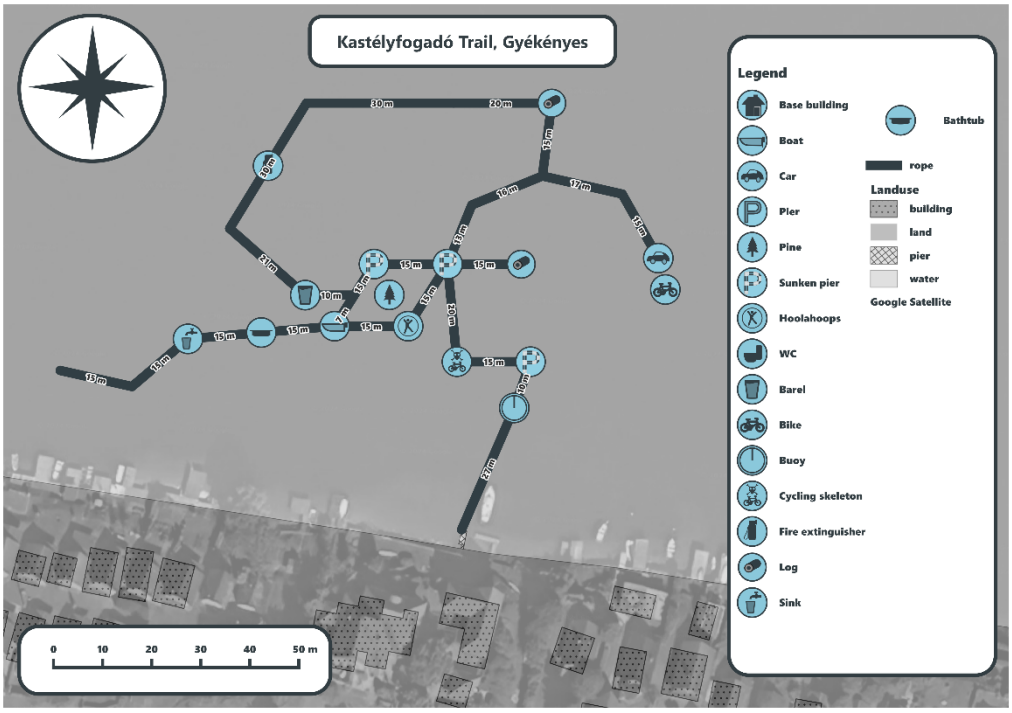
Divers who choose the alternate route after the pine tree will follow a slightly shorter but equally exciting path. This path leads to a motorbike after approximately 30 meters, followed by a sailing boat just 40 meters further. The trail then continues for 20 meters, culminating at the sunken motorboat as well, which is a unique sight and a key attraction along this secondary route.

As the two routes join together at the sunken motorboat they form a circle, so for divers who want to see all the attractions it can be done as one trail. Throughout the entire trail, a series of guide ropes ensure that divers can safely navigate between the

various points of interest. The lengths of the ropes range from 10 meters to 70 meters, depending on the distance between objects. This ensures that the trail is easy to follow, even for those with limited underwater navigation experience. The ropes are particularly helpful in maintaining a coherent path as the trail splits into two distinct sections, allowing divers to choose their preferred route while remaining connected to the overall trail network.

5.5.3 Gyékényes Kastélyfogadó Trail

The Gyékényes Kastélyfogadó Underwater Trail is a recreational diving route designed



to offer an engaging experience for divers exploring submerged objects in the Gyékényes quarry as well. This trail presents a unique blend of man-made and natural underwater features, all carefully connected to guide divers through the landscape.

Fig 14 – Gyékényes Kastélyfogadó Trail

The trail begins at the pier, marked by a 27-meter section of rope that stretches into the open water. This initial length serves as a pathway to guide divers to the first marked feature, a buoy. This buoy not only marks the beginning of the actual trail but also functions as a critical junction point

Following the main section of the trail from the buoy, the first notable feature is a sunken pier located just 10 meters away. This pier is an important part of the underwater landscape, giving divers an intriguing view of a man-made structure lying beneath the water's surface. From this point, the trail leads divers 15 meters further to a "Cycling Skeleton," a whimsical addition to the dive site. This submerged artpiece of a skeleton and bicycle serves as a reminder of both the recreational and artistic intent behind the creation of the trail.

Continuing 20 meters along the rope, divers encounter another sunken pier. This second pier, located deeper into the trail, adds to the sense of adventure, offering divers a chance to explore more of the submerged infrastructure. Another 15 meters ahead, the trail reveals a barrel, an item that may have once been used on the surface, now resting quietly in the aquatic environment. This object adds an element of history to the trail.

The next series of attractions begins with a boat, located just 7 meters after the Barel. The boat, though small, is a striking feature, giving divers the feeling of an abandoned vessel frozen in time. Just 15 meters ahead of the boat, the trail introduces a series of playful features, such as "Hoolahoops" and a "Bathtub." These objects evoke curiosity and add a fun, imaginative element to the experience. Following this, at a distance of 15 meters, divers will find a sunken "Sink"—an unexpected household item turned underwater landmark.

Further along, after traveling another 15 meters, divers are greeted by a "Pine" tree, one of the few natural elements integrated into the trail. This provides a moment of contrast with the man-made objects, highlighting the interaction between nature and human-made structures in the underwater world. A short distance of 15 meters ahead, divers encounter a submerged log, marking the transition from the first to the second part of the trail.

For those who choose to follow the second route – the longer one - from the buoy, the journey begins with a "Fire Extinguisher" located 15 meters from the buoy. This item, once used as an emergency device, now rests quietly underwater. Continuing 15 meters ahead, divers will find another log, this one marking the midpoint of the

alternative route. From here, the trail leads to larger objects, including a "Car" situated 30 meters ahead. This sunken vehicle is a highlight of the trail, offering divers an impressive sight as it sits on the quarry floor.

Adjacent to the car is a submerged "Bike," located just 15 meters away. This object is another quirky addition to the trail, adding to the variety of items found along the route. From the bike, the trail loops back toward the buoy, creating a closed circuit that divers can follow with ease.

Throughout the trail, all objects are connected by carefully placed ropes, ensuring divers can follow the route without difficulty. These ropes, ranging in length from 7 meters to 30 meters, are essential in guiding divers safely from one point to the next, maintaining clear direction even in lower visibility. The carefully designed layout of the ropes ensures that divers of all experience levels can comfortably navigate the trail while enjoying the diverse range of underwater features.

5.5.4 Gyékényes Diving Galactic Trail

The Gyékényes Diving Galactic Trail is a recreational underwater trail located in the serene waters of a quarry lake in Gyékényes, Hungary. Designed for both beginner and experienced divers, the trail offers a fascinating underwater experience, featuring a mix of sunken objects, submerged structures, and natural elements. This trail stands out not only for its immersive diving experience but also for its size, as it holds the distinction of being the largest underwater trail in Hungary as of 2024.

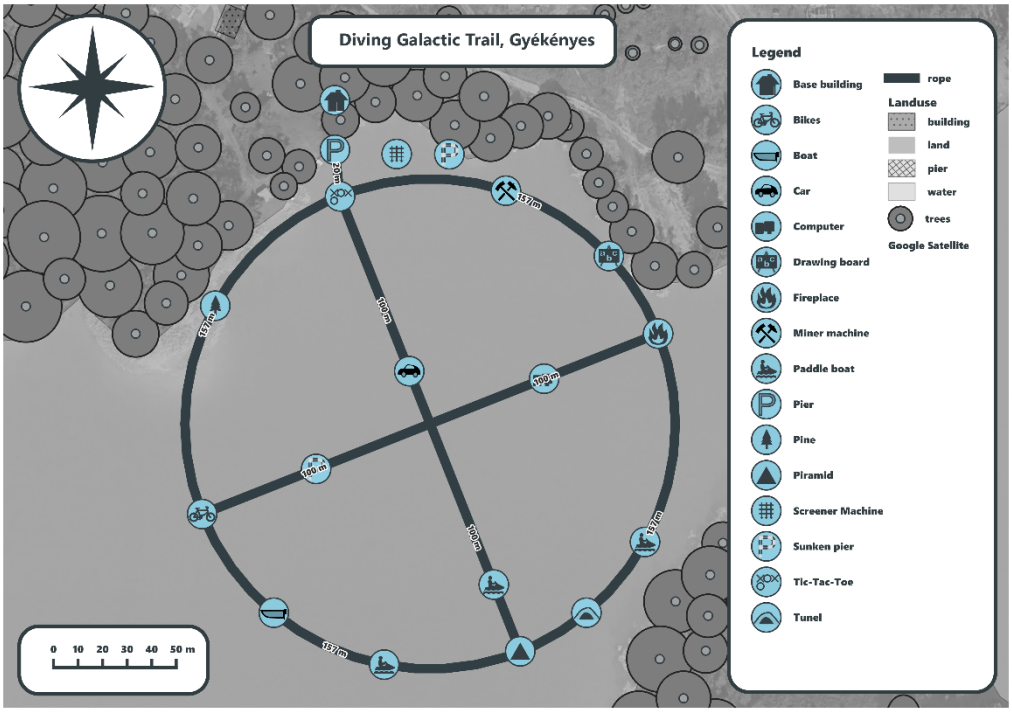


Fig 15 – Gyékényes Diving Galactic Underwater Trail

The trail begins at a pier that serves as the central starting point for divers. This pier is not only a practical entry point but also marks the beginning of the trail's underwater journey. From the pier, divers follow a rope that leads them to an installation called tic-tac-toe an underwater version of the popular children's game, which acts as a key junction. At this point, the trail splits into three sections, offering divers the opportunity to explore different paths while still being connected by a central rope network that forms a cross in the middle of the circular layout.

The trail then offers the option to explore either side of the split of the circle or swim through the middle of it directly. Following the right section of the trail from the buoy, divers will come across a Sunken pine, serving as an artificial habitat for fishes, then continue to the bikes, which are underwater vehicles placed playfully in the bottom.

In the middle section the trail leads to the Car, an old, submerged vehicle that has become a central point of interest.

Going left from the tic-tac-toe, divers encounter various industrial relics like the Screener Machine and the Miner Machine, both remnants of the site's former use as a

quarry. These artifacts not only provide a visual contrast to the natural elements but also remind divers of the region's industrial history.

At this point, divers arrive to a fireplace, an object placed underwater as an element of surprise. The next feature, the tunnel an intriguing structure offering an opportunity to swim through a confined, tunnel-like space. Shortly after, a cluster of Paddle boats can be found, scattered at different depths, giving a sense of an abandoned shoreline left behind in the water.

Finally, the last sunken structure, a small pyramid, is located along a rope that spans approximately 100 meters. It is the furthest point of the dive from the stating point and connects to 3 ropes. From here divers can either reach the Tic-Tac-Toe, or continue their circle to the already mentioned section of the dive.

The entire trail is connected by a system of ropes, ensuring divers can easily follow the route without losing their way. The total length of the ropes connecting these objects varies between 100 and 157 meters, with the ropes carefully positioned to account for visibility and ease of navigation. This ensures that divers can smoothly transition from one point of interest to another while staying on course.

6. Recommendations for Future Underwater Trails in Hungary

In designing future underwater trails in Hungary, it is essential to balance ecological and touristic priorities to maximize both environmental value and visitor engagement. Underwater trails offer a unique opportunity to highlight the submerged natural beauty, as well as local wildlife, and to educate the public on the importance of aquatic ecosystems.

This chapter outlines two key features ecological and tourism studies, that should be incorporated into future trails. These designs aim to serve two distinct but interconnected purposes: enhancing the ecological value of underwater environments and enriching the visitor experience by providing engaging, educational content.

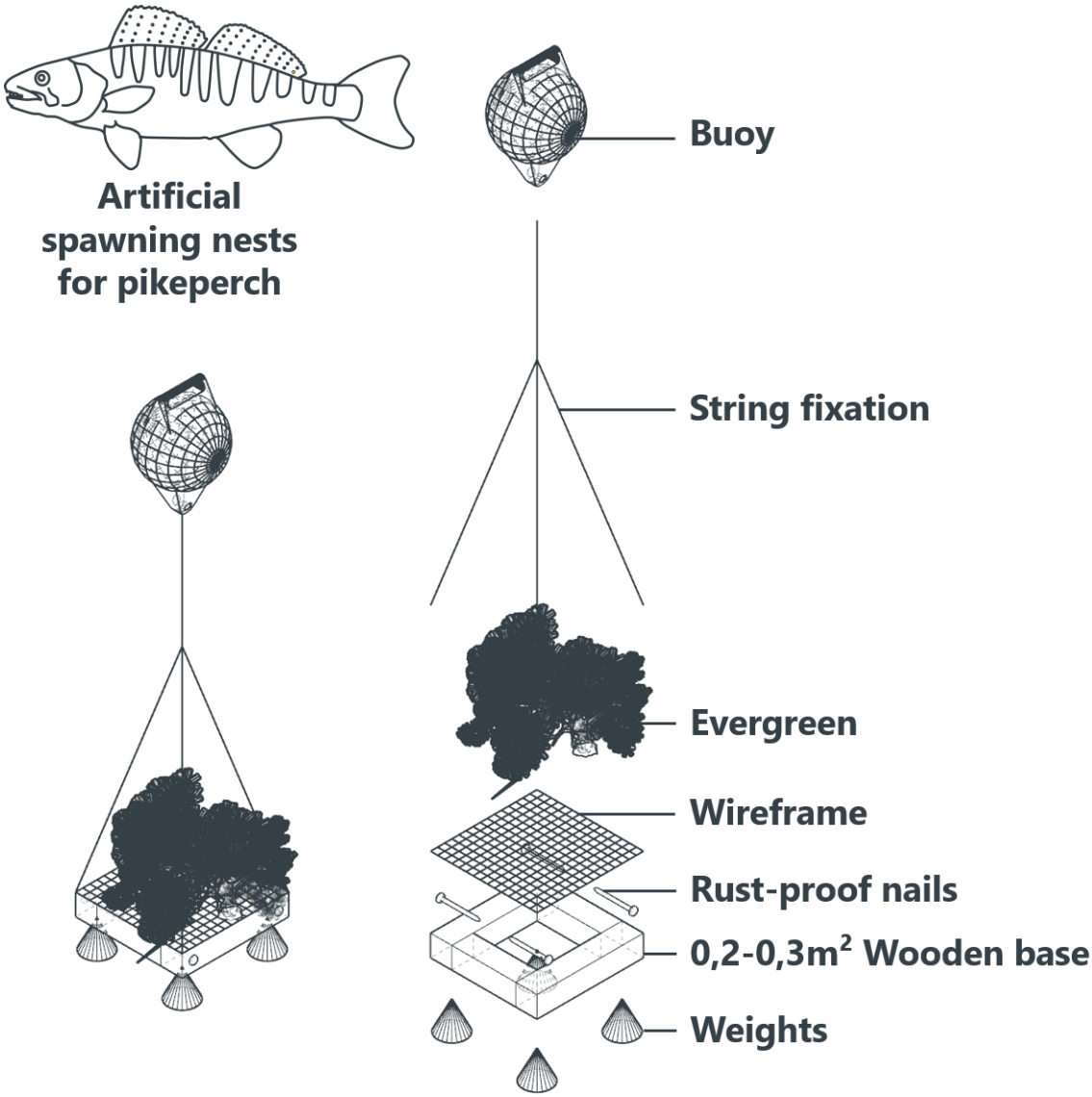
Both designs have been carefully developed to integrate into the natural underwater landscape while remaining practical and sustainable in their construction and implementation.

6.1. Suggestions for tools to use on underwater trails

As a guide for future underwater trails, or as recommendations for the improvement of existing ones, two specific features were designed: one with ecological goals and the other with a focus on enhancing the touristic experience.

The first feature, artificial spawning nests for pikeperch, supports local biodiversity by providing suitable breeding habitats for an important species, ensuring that ecological sustainability is at the heart of the trail design. The second feature, underwater signs, caters to the educational and aesthetic needs of visitors, helping them engage with the environment more deeply while exploring the trail. Both features contribute to a more comprehensive underwater experience, merging nature conservation with tourism.

6.1.1. Suggestion for Environmental Value Improvement: Artificial Spawning Nests



for Pikeperch

Fig 16: Artificial Spawning nest design for pikeperch

As part of the ecological enhancement of underwater trails, the installation of artificial spawning nests for pikeperch (*Sander lucioperca*) is proposed. This design aims to support the reproduction of this economically and ecologically important species, thereby enriching local biodiversity.

The design of these artificial nests is adapted from the work of Németh Ádám (Németh. Á, 2013). The primary goal is to replicate the natural conditions that

pikeperch prefer for spawning, using materials that promote sustainability and ecological compatibility.

The artificial spawning nest consists of the following key components, as illustrated in the attached diagram:

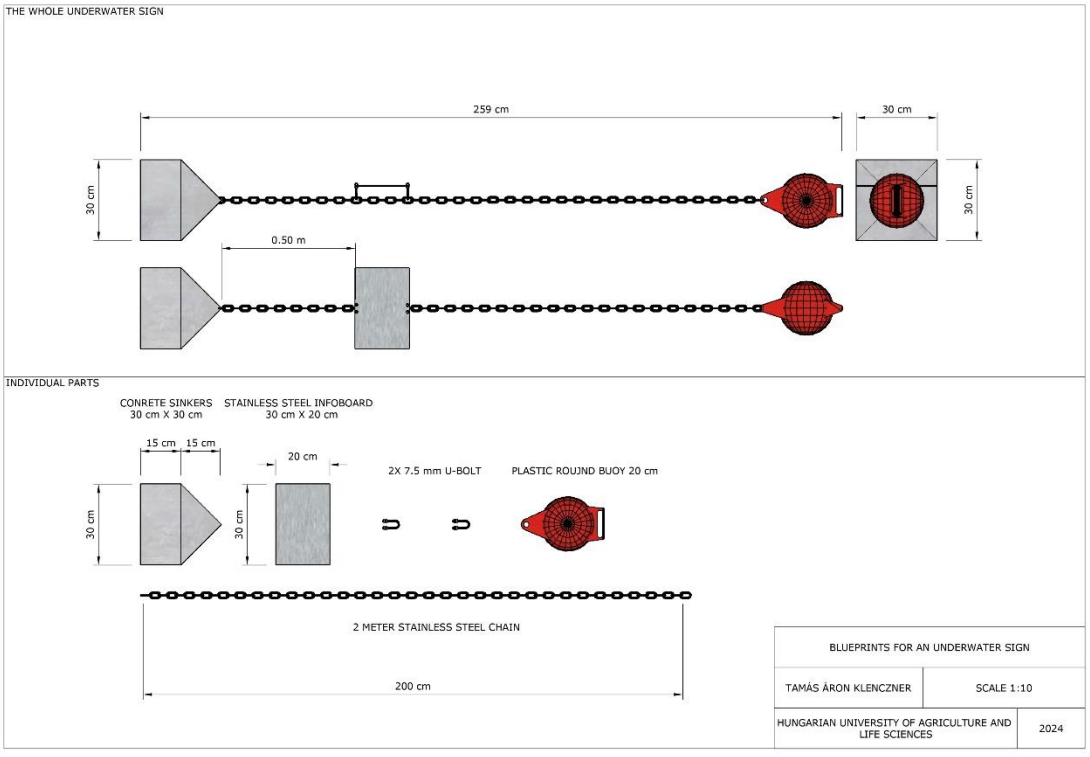
- **Wooden Base (0.2–0.3 m^2):** The base of the nest provides stability and a foundation for the structure. It is constructed from durable wood, fastened together using rust-proof nails to ensure long-term resistance to underwater conditions.
- **Evergreen Vegetation:** To mimic the natural environment pikeperch prefer during spawning, evergreen plants (such as pine or fir branches) are attached to the structure. The dense foliage provides an ideal substrate for the attachment of fish eggs, simulating the submerged vegetation commonly used by the species for reproduction.
- **Wireframe Support:** A wireframe structure is used to hold the evergreen branches in place and to provide structural integrity. This prevents the vegetation from floating away or deteriorating quickly, allowing the nests to remain functional throughout the breeding season.
- **Buoy and String Fixation:** A buoy attached to the top of the structure via string ensures the spawning nest remains visible and easy to relocate for monitoring and maintenance. The buoy also helps adjust the height of the nest within the water column, placing it in optimal conditions for pikeperch spawning.
- **Weights:** Small weights are attached to the wooden base to keep the structure anchored to the lakebed, ensuring it is not displaced by currents or wind-induced water movement.

This nest design offers several ecological benefits. By providing artificial yet natural-like spawning sites, the nests encourage the successful reproduction of pikeperch, which can lead to an increase in their population within the area. Additionally, as pikeperch is a predatory species, their presence helps maintain a balanced ecosystem by controlling the populations of smaller fish and invertebrates.

The artificial spawning nests should be strategically placed in relatively shallow, calm sections of lakes or reservoirs along underwater trails. Ideal locations are those where natural spawning habitats (such as submerged vegetation) are scarce. Regular monitoring and maintenance of the nests will be necessary, especially after the spawning season, to ensure the integrity of the structures and the success of the fish population.

This recommendation, based on the work of Németh (2013), could significantly contribute to the ecological sustainability and attractiveness of future underwater trails in Hungary. It not only enhances biodiversity but also offers a practical demonstration of habitat restoration and species conservation in action.

6.1.2. Suggestion for Touristic Value Improvement: Underwater Signs



The design I developed for the underwater sign consists of the following parts:

- **The Underwater Trail Sign:** The overall dimensions of the sign are 260 cm in length, 30 cm in width, and 30 cm in height. The relatively large size of the sign was determined to ensure visibility underwater and to provide uplift through a single buoy. The sign itself was determined to be placed at 50 cm from the base

to negate the effects of sediment that can reduce clarity. Additionally, the sign's length allows it to be anchored securely while standing out as a prominent marker within the aquatic environment.

The main structural components of the underwater sign include a concrete sinker, a stainless steel chain, a stainless steel infoboard, a plastic round buoy, and stainless steel U-bolts, each of which plays a vital role in ensuring stability, durability, and accessibility.

- **Concrete Sinkers:** The base of the underwater sign consists of two concrete sinkers, each measuring 30 cm x 30 cm. These sinkers provide the necessary weight to anchor the entire structure securely to the lake or seabed, preventing it from drifting or shifting due to underwater currents, wave action, or interaction with marine life. Concrete was chosen as the primary anchoring material due to its durability, resistance to corrosion, and environmental compatibility. Importantly, concrete is non-reactive in freshwater environments, ensuring that it does not leach harmful substances into the ecosystem. The use of concrete also minimizes disturbance to the surrounding habitat, as it blends well with natural aquatic substrates such as sand and gravel.

- **Stainless Steel Infoboard:** Positioned 50 cm above the concrete sinkers, the infoboard is one of the most crucial elements of the underwater trail sign. Constructed from stainless steel and measuring 30 cm x 20 cm, it offers ample space to display educational content for divers. Stainless steel was selected for its corrosion resistance, particularly in aquatic conditions, ensuring long-term durability. This material choice reduces the need for frequent maintenance and replacements, making the sign more sustainable over time.

  The infoboard will feature essential information about the surrounding underwater species, providing divers with educational content about local species, geological features, and conservation efforts. The height at which the board is placed (50 cm from the base) ensures that divers of various experience levels can easily view it without disturbing the lakebed or delicate underwater

ecosystems. This height also prevents potential sediment buildup on the sign. The sign should also have a clear, black and white or high contrast imagery to ensure visibility for a long period of time during the lifetime of the sign.

- **Plastic Round Buoy:** At the top of the structure is a round buoy made of plastic, measuring 20 cm in diameter and 30 cm in height. The buoy serves two primary functions: buoyancy control and visibility. The buoy ensures that the sign maintains an upright position, preventing it from tilting or falling over, which is essential for both its effectiveness and longevity. The buoy also helps divers locate the sign from a distance, as its bright colour contrasts against the typically muted tones of underwater environments.

  The plastic used in the buoy was carefully selected for its durability and non-toxic properties. It is critical that any materials placed in sensitive freshwater environments do not contribute to pollution. The buoy's design is streamlined to reduce drag and minimize disruption to the underwater flow of water, further ensuring that it does not disturb the natural habitat.

- **200 cm Stainless Steel Chain:** To provide additional security and ensure the sign remains stable in varying underwater conditions, a 200 cm stainless steel chain is integrated into the design. This chain acts as a secondary anchoring mechanism, linking the buoy or sign to a more secure point on the lakebed or another structure. The chain's stainless steel composition is ideal for underwater applications, offering excellent resistance to corrosion and wear in freshwater environments.

  The inclusion of the chain also adds flexibility to the design, allowing the sign some degree of movement to adapt to shifts in currents or divers' interactions while remaining firmly anchored. Its length of 200 cm was chosen to provide a balance between stability and mobility, ensuring the sign maintains its position without becoming overly rigid.

- **Stainless Steel U-Bolts and Connecting Structure:** The various components of the sign are connected using stainless steel U-bolts, each measuring 7.5 mm in diameter and 2 meters in length. These U-bolts are essential in securing the

buoy, infoboard, and concrete sinkers together, creating a sturdy and cohesive structure. The use of stainless steel ensures that the bolts resist rust and corrosion, which is particularly important in underwater installations where constant exposure to water can cause rapid degradation of materials.

In addition to their practical function, the U-bolts provide a certain degree of flexibility in the design. They allow the sign to be modular, enabling easy adjustments or replacements of individual parts without disturbing the entire structure. This modularity is beneficial for both maintenance and future modifications, should updates to the educational content or structural design be necessary.

The materials chosen for this underwater trail sign were selected not only for their functional properties but also for their minimal environmental impact. Eco-friendly materials such as concrete, stainless steel, and non-toxic plastics are crucial for reducing the ecological footprint of the sign. These materials have a long lifespan in underwater environments, reducing the frequency of replacements and the potential for pollution. Furthermore, the design is intended to be low-impact in terms of installation and maintenance, ensuring that the surrounding aquatic environment remains undisturbed.

The underwater trail sign serves as both a functional guide for divers and an educational tool that promotes environmental awareness. By integrating eco-friendly materials and thoughtful design, the sign will contribute to a sustainable underwater tourism experience while helping to preserve and protect freshwater ecosystems.

6.2. Educational Value: Enhancing the Diver's Experience through Signage

In addition to enhancing the ecological aspects of underwater trails, it is important to provide visitors with visual and educational content that makes their exploration more engaging and informative. Generally, key aspects of the design include

- **Educational Information:** Each sign would feature detailed information about the specific underwater flora and fauna present along the trail. For example,

signs could highlight the local fish species, and their roles within the ecosystem. In addition, they would provide information on conservation efforts, encouraging visitors to understand the importance of protecting these environments.

- **Aesthetic Value:** Beyond their informational role, these signs would be designed with artistic and aesthetic value in mind. Using natural motifs or depictions of local aquatic life, the signs can contribute to the visual appeal of the trail. Additionally, the placement of these signs would be considered carefully to avoid disrupting the natural beauty of the underwater environment.

To illustrate this concept, we have developed a sign design for a specific fish species, Scardinius erythrophthalmus (Common Rudd). The sign is divided into two columns and includes a high-contrast black and white illustration of the fish at the top, along with its common and scientific names.

Fig 17 – design of the content of the sign itself

The content of the sign (MOHOSZ, 2024) is as follows:

“Common Rudd (Scardinius erythrophthalmus)”

"Origin: Native to parts of Asia and Europe, including Hungary. Interestingly, it has become invasive in other parts of the world."

I included this information to provide geographical context and highlight the species' native status in Hungary. By mentioning its invasive nature elsewhere, I aimed to subtly introduce the concept of ecosystem balance and the potential impacts of species introduction.

"Appearance: This slender, silver-bodied fish species, adorned with golden and green hues, is easily recognizable by its distinctive reddish fins. Its streamlined shape and forked tail fin allow for quick maneuvering in the water."

I provided this detailed description to help divers easily identify the species underwater. By mentioning its physical characteristics and movement abilities, I aimed to enhance the divers' observational skills and engagement with the marine life they encounter.

"Habitat: The Common Rudd inhabits various freshwater environments, including lakes, rivers, and ponds. They prefer shallow, vegetated areas where they find both shelter and food."

I included habitat information to give divers context about where they might spot this species. This knowledge can help them understand the fish's preferred environments and potentially improve their chances of observation.

"Diet: As an omnivorous feeder, it follows a diverse diet consisting of aquatic plants, algae, small invertebrates, and insect larvae. Their feeding habits contribute to the balance of aquatic ecosystems by regulating vegetation growth and insect populations."

By detailing the species' diet and its impact on the ecosystem, I aimed to illustrate the interconnectedness of aquatic life. This information helps divers understand the fish's role in maintaining ecological balance.

"Reproduction: During the spawning season, typically in spring or early summer, they build shallow nests in submerged vegetation where females lay their eggs. After

hatching, young individuals seek shelter in shallow, vegetated areas until fully developed."

I included reproductive information to provide insight into the species' life cycle. This can encourage divers to visit at different times of the year to observe various life stages, enhancing their overall understanding of the species.

"Ecological Impact: As a native species, they play a role in shaping aquatic ecosystems, serving as prey for larger predators and contributing to nutrient cycling."

This information further emphasizes the species' role in the ecosystem. I included it to help divers appreciate the importance of each species in maintaining ecological balance.

"Adaptability: Known for its ability to adapt to various environmental conditions, it has successfully spread across freshwater habitats throughout Europe, including Hungary. When embarking on underwater adventures in Hungary, keep an eye out for the Common Rudd with its distinctive red fins, a testament to the rich biodiversity of the region's waters."

I concluded with this information to highlight the species' resilience and widespread presence in Hungary. By encouraging divers to look for the Common Rudd, I aimed to create a connection between the educational content and their actual diving experience, enhancing engagement and appreciation for local biodiversity.

The text and images are printed with high-contrast, water-resistant inks to ensure readability even in low-light conditions. The sign should also be made in multiple languages, the other language variant could be added to the other side of the buy, providing the information in both Hungarian and English, making the sign accessible to a wider range of visitors, enhancing its educational reach.

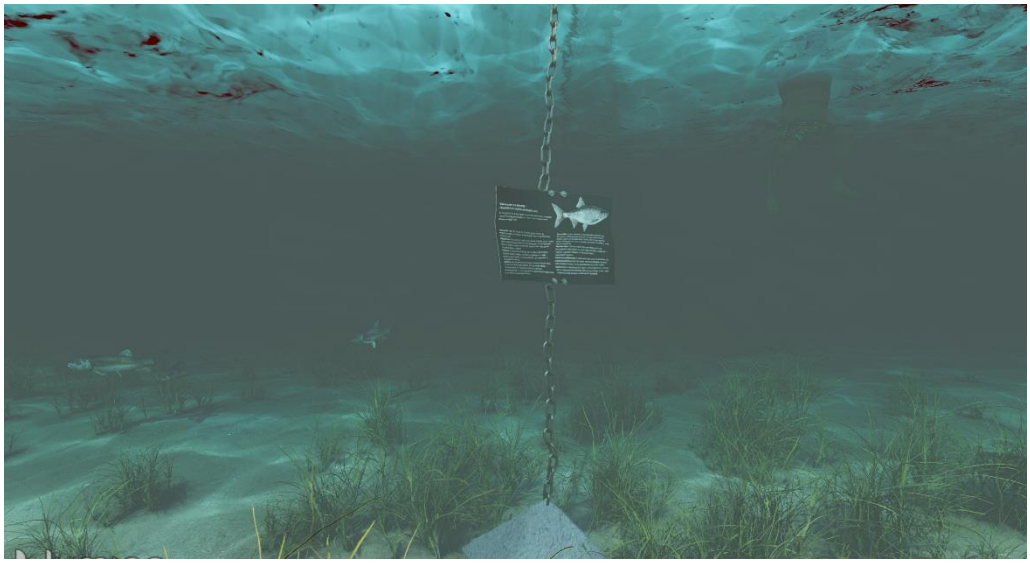


Fig 18 -visualization of how the sign would look underwater

6.3. Strategies for Boosting Dive Tourism in Hungary

Hungary, with its diverse freshwater ecosystems, has significant potential to become a more prominent destination for dive tourism. To capitalize on this potential while maintaining a balance between tourism and conservation, several strategies can be implemented.

Firstly, developing a network of well-designed underwater trails across various locations in Hungary can serve as a cornerstone for boosting dive tourism. These trails should be carefully planned to showcase the unique biodiversity of Hungary's freshwater environments, including lakes, rivers, and quarries. By creating trails that highlight different ecosystems and species, we can cater to a wide range of interests and skill levels among divers.

Implementing a comprehensive marketing strategy, based on the touristic potential values of each site described already, is crucial to attract both domestic and international divers. This should include creating a strong online presence through a dedicated website and social media channels, showcasing the unique diving experiences Hungary has to offer. Collaborating with travel bloggers, dive magazines, and influencers in the diving community can help spread awareness about Hungary's underwater attractions.

Establishing partnerships with local dive shops, tour operators, and accommodation providers is essential to create attractive package deals for tourists. These packages could include diving experiences, accommodation, and cultural activities, providing a well-rounded experience that goes beyond just diving. This approach not only enhances the appeal of Hungary as a dive destination but also benefits the local economy.

Investing in infrastructure to support dive tourism is another critical aspect. This includes developing dive centres with modern facilities, ensuring easy access to dive sites, and providing necessary amenities such as gear rental services and air fill stations. Additionally, creating artificial reefs or underwater sculptures in suitable locations can add to the appeal of dive sites and provide new habitats for aquatic life.

Organizing regular events such as underwater photography contests, conservation workshops, and dive festivals can help maintain interest and encourage repeat visits. These events can also serve as platforms to educate visitors about the importance of conservation and responsible diving practices.

Training local guides and dive instructors is crucial for providing high-quality experiences to visitors. These professionals should not only be skilled in diving techniques but also knowledgeable about local ecosystems, conservation efforts, and the cultural significance of various dive sites. This approach ensures that visitors receive a comprehensive and educational experience.

Implementing a sustainable tourism model is paramount to ensure the long-term viability of dive tourism in Hungary. This includes setting carrying capacities for dive sites, implementing rotation systems to prevent overuse of popular locations, and establishing strict guidelines for responsible diving practices. Regular monitoring of the ecological impact of diving activities should be conducted, with adaptive management strategies in place to address any negative effects promptly.

Collaborating with research institutions and conservation organizations can provide valuable insights into the health of aquatic ecosystems and inform management decisions. This scientific approach can also be leveraged to create citizen science

programs, allowing divers to contribute to research efforts and feel more connected to the environments they explore.

Lastly, developing a certification program for dive operators who adhere to strict environmental and safety standards can help ensure the quality of diving experiences while promoting responsible tourism practices. This certification can serve as a mark of quality for tourists when choosing dive operators.

6.4 Surface Recommendations Example: A Landscape Architecture perspective on the Palatinus Lake

When designing underwater trails one must consider the elements not only bellow but above. To better illustrate what elements need to be present in a diving location above water, I have assessed the challenges and land use conflicts presented on an already existing location, the Palatinus Lake diving site. This location was already mentioned in the section where the existing underwater trails were mapped, the site is located on the northern part of the Palatinus lake.

The Palatinus Lake diving site (Plan 1) presents both significant opportunities and challenges for landscape architectural intervention. As an established diving location with existing infrastructure, including basic facilities and recreational amenities, the site serves as a foundation for thoughtful development and enhancement. However, the current condition of various elements - from deteriorating wooden decks to poorly defined parking areas and a relatively small bathroom facility within the base building - necessitates a comprehensive approach to surface treatment and spatial organization.

This section examines the current state of the area, identifies the land use conflicts, and suggests improvements and recommendations for the site's surface elements, considering both the technical requirements of a diving facility and the broader environmental and user experience aspects. The analysis and subsequent recommendations are structured to address the site's existing conditions while proposing sustainable solutions that enhance functionality, safety, and aesthetic appeal. Through careful consideration of materials, spatial organization, and ecological factors, these recommendations aim to transform the Palatinus Lake

diving site into a more cohesive, environmentally conscious, and user-friendly facility that serves both the diving community and casual visitors while respecting the natural landscape.

6.4.1 Identified Land-Use Conflicts

Based on the current status of the area, I have identified the following conflicts in land-use:

Ecological Conflict 1 – Soil degeadation due to parking

The current informal parking arrangement on unpaved grass areas has led to severe soil compaction issues, particularly evident during peak diving seasons. This compaction has resulted in reduced soil permeability and degraded grass coverage, creating bare patches that are susceptible to erosion during rainfall events.

Ecological Conflict 2 – Lack of trees in the parking area

In the parking area apart from the soild degradatio there is a lack of trees which result in not only the lack of shade but more importantly the lack of an ecologically active zone in the area

Ecological Conflict 3 – The state of the existing reeds

The existing reeds, which provide crucial habitat for local wildlife and help maintain water quality, lack proper protection zones. Current user patterns show frequent unauthorized access through these sensitive areas, leading to habitat fragmentation and degradation of the reed ecosystem.

Functional Conflict 1 – The Lack of Changing Facilities.

The existing changing facilities are severely undersized for the site's user volume. Current capacity allows only 2-3 people to change simultaneously, creating long waiting times during peak hours. The facilities also lack proper ventilation and adequate storage for personal belongings. Furthermore there are no warming facilities for divers after the dives.

Functional Conflict 2: – Lack of distinction between pedestrian and vehicle trafic

The site's circulation pattern is problematic, with vehicles and pedestrians sharing undefined pathways. The current layout forces divers carrying heavy equipment to navigate through parking areas without dedicated walkways, creating safety hazards.

Functional Conflict 3: – Underused Volleyball courts

The two volleyball courts show signs of significant neglect. The lack of defined boundaries has allowed grass encroachment into the sand areas. Usage patterns indicate that two courts exceed current demand, resulting in wasted space.

Functional Conflict 4: – Lack of equipment preparation space

Equipment preparation currently occurs in ad-hoc locations around the base building, often exposing sensitive diving gear to direct sunlight and weather elements. The lack of dedicated assembly areas forces divers to prepare equipment on unstable or inappropriate surfaces.

Functional Conflict 5: – Lack of services for Non-diving visitors

Non-diving visitors, who often accompany divers, lack appropriate facilities. The absence of food service or comfortable waiting areas often results in shortened visits or decreased overall site usage.

Functional Conflict 6: –The state of the wooden deck

The wooden deck, estimated to be over 15 years old, shows significant structural wear. Loose boards, protruding nails, and degraded surfaces create safety hazards for divers carrying heavy equipment.

Fig 19: The current state of the wooden deck on location

Aesthetic Conflict 1: – The lack of spatial organization

The current spatial organization lacks clear hierarchical elements, creating visual confusion and inefficient use of space. The random placement of facilities and undefined boundaries between different use areas creates a cluttered appearance.

Aesthetic Conflict 2: – The lack of unified design language

The site lacks a unified design language, with various additions and repairs over time creating a patchwork of different styles and materials. This inconsistency detracts from the professional image of the diving facility.

Fig 20: The current state of the base is a mixture of unorganised, differently designed elements

These conflicts represent significant challenges that need to be addressed through careful design intervention, considering both immediate functional needs and long-term sustainability goals. These conflicts were mapped in a conflict map (Plan 3).

6.4.2 Design Solutions and Recommendations

Based on the Land Use Conflicts above and the international guides available (Vetrano, 2018), these are the recommendations I have for the area.

Ecological Solution 1 – Implementation of a comprehensive permeable paving system

Main driveway and parking spaces to be constructed with interlocking permeable pavers (20x10cm) in a herringbone pattern. Walkways to utilize smaller format (10x10cm) permeable pavers in a running bond pattern. All paving to be set on appropriate sub-base layers with proper filtration fabric to prevent soil migration

Ecological Solution 2 – Strategic native tree planting scheme for parking area

Tilia cordata (Small-leaved lime) as primary shade trees, placed at 4-meter intervals . Selected for dense canopy providing optimal shade. This species has deep root system compatible with parking infrastructure and natural resistance to urban conditions

Acer campestre (Field maple) as secondary species . It has drought-resistant characteristics, It's compact crown suitable for smaller spaces and the excellent autumn colour for seasonal interest

Fraxinus angustifolia (Narrow-leafed ash) for peripheral planting. This species Fast-growing nature helps with quick establishment, it is adaptable to various soil conditions and provides filtered shade without excessive leaf litter

Ecological Solution 3 – Enhanced reed bed protection system

Creation of 3-meter buffer zones with native marginal plants, where visitors are not allowed to enter. Also

Functional Solution 1 – Modern changing facility building

The new building (~80m²)has separate changing areas for men and women, there are individual changing cubicles with benches and hooks, also secure lockers of various sizes. Next to the bathrooms there are six shower stalls in total. There is also a universal access bathroom. The whole building has energy-efficient heating and ventilation systems. Also a small sauna with a lake view is planned to help divers relax and warm up after the dives.

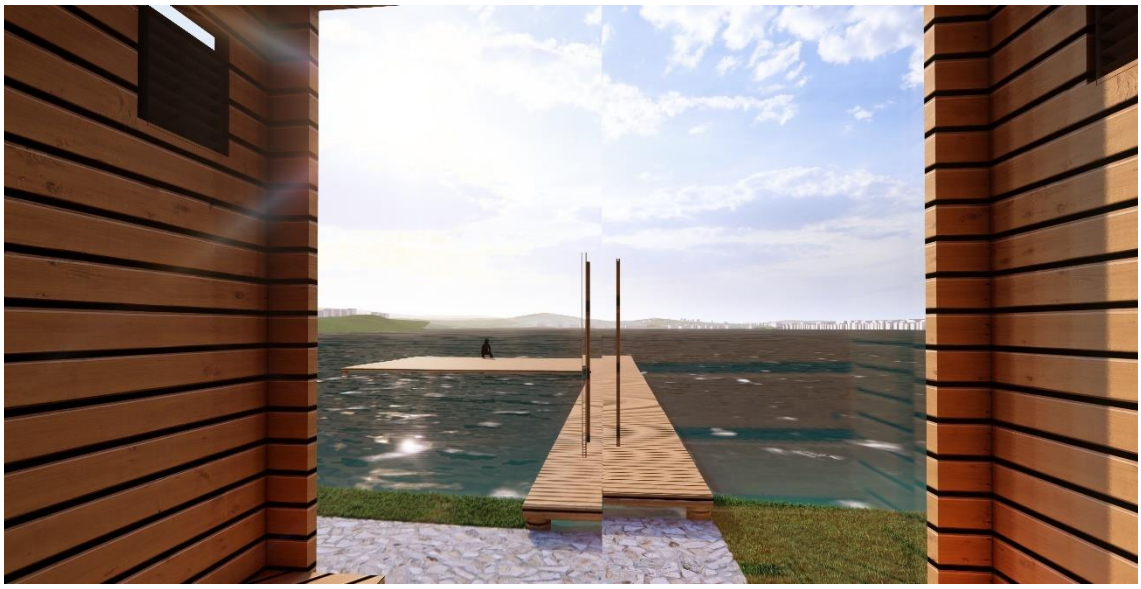


Fig 21: The proposed Sauna

Functional Solution 2 – New parking layout design

The new layout of the parking areas has 24 clearly marked spaces (2.4m x 5m each), it also shows a one-way circulation pattern with 8m wide driving lanes and has a dedicated loading/unloading zones near pathway entrance.

Functional Solution 3 – Renovated volleyball court

the new court should have professional-grade sand depth (40cm) with proper drainage system. The permanent court boundaries should be maintained all times and there is a new net system with adjustable height

Fig 22: The renovated volleyball court

Functional Solution 4 – Equipment assembly and repair area

There is an 60m²area with three tensile shade sails providing UV protection and allowing divers to assemble their gear undisturbed.

Functional Solution 5 – Café facility

The new Café has an outdoor area with tables (40m²), it has a full-service kitchen facility, its front is facing lake for optimal view and it has year-round operation capability.

Fig 23: The Proposed Café Building with the chairs on the left, and the changing facility building on the right

Functional Solution 6 – New wooden deck construction

The new deck should be made of-treated timber with a non-slip surface treatment. This can be achieved by renovating the existing structure.

Fig 24: The proposed new deck

Aesthetic Solution 1 – Cohesive pathway system

The main walkways are 2.5m wide for equipment transport, the secondary path is 1.2m wide for general circulation. There is a clear sight lines to key facilities

Fig 25: the new pathway system from above

Aesthetic Solution 2 – Design language consistency

The new buildings and elements should have a natural material palette (wood, stone, metal), with a coordinated colour scheme across all elements. The architectural details should be unified integrating local cultural elements.

This comprehensive solution set addresses the identified conflicts while creating a cohesive, functional, and aesthetically pleasing environment that serves both the diving community and casual visitors. The design emphasizes sustainability, functionality, and user comfort while maintaining the site's natural character. These suggestions have been mapped in a comprehensive general plan (Plan 2)

6.4.3. Transferable Design Principles and Lessons Learned

The comprehensive analysis and proposed solutions for the Palatinus Lake diving site offer valuable insights that can be applied to other diving facilities. These lessons learned can be categorized into several key areas:

- **Infrastructure Planning and Organization:** The importance of clear spatial hierarchy in diving facilities has emerged as a crucial factor. The separation of different functional zones (parking, preparation, diving, social) creates an efficient flow of activities and reduces potential conflicts.
  The implementation of dedicated equipment preparation areas with weather protection has proven essential for diving operations. This feature should be considered a standard element in any diving facility design.
  The provision of adequate changing and sanitary facilities should be calculated based on peak usage patterns rather than average daily numbers, with a recommendation of one changing cubicle per 15-20 regular users.
- **Environmental Considerations:** The integration of permeable surfaces for parking and pathways has demonstrated both ecological and practical benefits. This approach can be particularly valuable for facilities located near water bodies where drainage and water quality are concerns.
  Strategic native tree placement serves multiple functions. It provides necessary shade for parking and social areas, it reduces heat island effects, enhances biodiversity
  The protection of natural shoreline features (such as reed beds) through designated buffer zones and controlled access points can be adapted to various waterfront conditions.
- **User Experience Enhancement:** The inclusion of facilities for non-diving visitors has shown to be crucial for the overall success of diving bases. This

includes comfortable viewing areas, Food and beverage services and seating areas with clear sight lines to diving activities. Creating weather-protected spaces for year-round operation, particularly in regions with variable climate conditions is important.

- **Safety and Functionality:** The design of water access points (such as wooden decks) should prioritize non-slip surfaces with an adequate width for two-way traffic. It should be built using robust construction methods and regularly maintained for accessibility
- **Adaptability and Future-Proofing:** Designs should incorporate flexibility for future expansion or modification of facilities. Infrastructure should be planned with consideration for changing technologies in diving equipment and training methods. Maintenance requirements should be considered during the design phase to ensure long-term sustainability.

These lessons provide a valuable template for the development or improvement of diving facilities while maintaining site-specific adaptability. The success of these principles at the Palatinus Lake site demonstrates their potential for broader application in the diving facility design field.

7. Conclusion

7.1. Summary of Findings

This research has yielded several significant findings that contribute to our understanding of underwater trails in Hungary's freshwater environments and their potential for sustainable tourism development.

Firstly, this study revealed a strong correlation between visibility, depth, and substrate type at Hungarian dive sites. Sites with sandy or rocky substrates generally offered better visibility, especially at greater depths. This information is crucial for dive trail planning and site selection, as visibility significantly impacts diver experience and safety.

The development of a novel touristic value calculation method allowed for a quantitative assessment of Hungarian dive sites. This method, which considers factors

such as visibility, depth, substrate type, and unique features, provided valuable insights into the potential of various locations for dive tourism. Interestingly, the calculations showed a strong positive correlation with user reviews from divecenter.hu, validating the effectiveness of the method.

My survey of 43 professional divers in Hungary yielded important insights into diver preferences and behaviors. The results indicated that a majority of respondents dive in freshwater locations in Hungary at least once a month, highlighting the importance of these sites for the local diving community. Overall diving experience ratings were generally positive, with factors such as water clarity, unique underwater features, and ease of access significantly influencing site selection. Challenges encountered by divers primarily included poor visibility and lack of interesting underwater features, emphasizing areas for potential improvement.

The study also produced a comprehensive dive site inventory, mapping the distance of various locations from the capital city, Budapest. This analysis revealed a correlation between a site's proximity to the capital and its popularity, suggesting that accessibility plays a crucial role in dive site utilization.

Field research allowed for detailed mapping of existing underwater trails in Dorog and Gyékényes. These maps provide valuable resources for dive operators and individual divers, enhancing safety and navigation underwater. The Dorog Diving Museum Trail stood out for its unique educational value, showcasing various diving equipment and artifacts. The trails in Gyékényes, particularly the Diving Galactic Trail, demonstrated innovative approaches to creating engaging underwater experiences in freshwater environments.

The research also highlighted the potential for enhancing both the environmental and touristic value of dive sites. My suggestion for introducing artificial spawning nests for pikeperch presents an opportunity to combine conservation efforts with dive tourism. Similarly, the proposed underwater signage system could significantly improve the educational value of dive trails while enhancing the overall diving experience.

Interviews with diving and water tourism experts provided valuable insights into the current state and future potential of dive tourism in Hungary. These discussions

emphasized the need for improved infrastructure, marketing efforts, and collaboration between stakeholders to boost the sector.

Lastly, the study underscored the importance of balancing tourism development with conservation efforts in freshwater environments. The recommendations provided for future underwater trails in Hungary aim to achieve this balance, promoting sustainable dive tourism while preserving the ecological integrity of these unique aquatic ecosystems.

This research has provided a comprehensive overview of the current state of underwater trails in Hungary's freshwater environments, identified key areas for improvement, and proposed innovative solutions to enhance both the touristic and environmental value of these sites. These findings lay a solid foundation for the future development of sustainable dive tourism in Hungary.

7.2. Contributions of the Study to Tourism and Conservation

This study makes several significant contributions to the fields of tourism and conservation, particularly in the context of freshwater diving environments:

- **Novel Touristic Value Calculation Method:** The development of a quantitative method to assess the touristic value of dive sites is a major contribution of this research. This tool can be adapted and applied to other regions, providing dive operators, tourism boards, and conservation agencies with a standardized way to evaluate and compare dive sites.
- **Comprehensive Mapping of Hungarian Dive Sites:** By creating detailed maps of existing underwater trails and compiling a comprehensive inventory of dive sites, this study provides valuable resources for both the diving community and tourism planners. These maps can enhance safety, improve dive planning, and aid in the marketing of Hungarian dive tourism.
- **Integration of Conservation and Tourism:** The study proposes innovative ways to combine conservation efforts with tourism development, such as the suggestion for artificial spawning nests for pikeperch. This approach demonstrates how dive tourism can actively contribute to ecosystem preservation and enhancement.

- **Enhanced Understanding of Diver Preferences:** The survey of professional divers provides insights into the factors that influence site selection and overall satisfaction. This information is crucial for dive operators and site managers in tailoring their offerings to meet diver expectations while maintaining ecological integrity.
- **Underwater Signage System:** The proposed underwater signage system represents a novel approach to enhancing the educational value of dive trails. This concept could be adapted for use in other freshwater and marine environments globally, contributing to diver education and environmental awareness.
- **Freshwater Dive Tourism Model:** By focusing on freshwater dive sites, this study contributes to the relatively understudied field of freshwater dive tourism. The findings and recommendations could serve as a model for developing sustainable dive tourism in other freshwater-rich regions around the world.
- **Policy Implications:** The research highlights the need for updated diving policies in Hungary, potentially influencing future legislation to better support sustainable dive tourism while ensuring adequate environmental protection.
- **Interdisciplinary Approach:** By combining elements of tourism studies and conservation biology with landscape architecture, this research demonstrates the value of interdisciplinary approaches in addressing complex issues in sustainable tourism development.
- **Local Economic Impact:** The study's focus on boosting dive tourism in Hungary could contribute to local economic development, particularly in quarry lakes where many of these dive sites are located.
- **Awareness of Freshwater Ecosystems:** By highlighting the unique features and conservation needs of freshwater dive sites, this study contributes to raising awareness about the importance and fragility of freshwater ecosystems.

This research not only advances our understanding of freshwater dive tourism in Hungary but also provides practical tools and recommendations that can be applied more broadly in the fields of sustainable tourism development and aquatic

conservation. The study bridges the gap between theoretical research and practical application, offering tangible solutions for balancing tourism growth with environmental preservation in freshwater ecosystems.

7.3. Final Thoughts on the Future of Diving Trails in Hungary

As I conclude this study, it is clear that Hungary's freshwater diving trails hold significant potential for growth and development. The future of these underwater trails is not just promising, but also crucial for the sustainable development of Hungary's tourism sector and the conservation of its unique aquatic ecosystems.

The research has revealed that Hungary possesses a diverse array of freshwater dive sites, each with its own distinct characteristics and appeal. From the educational Diving Museum Trail in Dorog to the innovative Diving Galactic Trail in Gyékényes, these sites demonstrate the creativity and potential that exists within the Hungarian diving community. However, to fully realize this potential, several key areas require attention and action:

- **Infrastructure Development:** Improving access to dive sites and enhancing on-site facilities will be crucial in attracting both domestic and international divers. This includes better road access, parking facilities, and dive support services.
- **Marketing and Promotion:** There is a need for targeted marketing strategies to raise awareness about Hungary's freshwater diving opportunities, both domestically and internationally. Collaboration with national tourism boards and international diving organizations could significantly boost visibility.
- **Environmental Conservation:** As dive tourism grows, it will be essential to implement and enforce strict conservation measures. The proposed artificial spawning nests for pikeperch serve as an example of how tourism development can go hand-in-hand with conservation efforts.
- **Education and Training:** Investing in diver education and training programs will be crucial. This includes not only dive skills but also environmental awareness and responsible diving practices.

- **Policy and Regulation:** There is a need for updated and comprehensive diving regulations that balance safety, conservation, and tourism development. Policymakers should work closely with diving experts and environmental scientists to craft effective legislation.
- **Innovation in Dive Experiences:** Continuing to develop unique underwater attractions, such as themed trails or underwater art installations, could set Hungarian dive sites apart and attract a wider range of visitors.
- **Community Engagement:** Involving local communities in the development and management of dive sites can ensure sustainable growth and distribute economic benefits more widely.
- **Research and Monitoring:** Ongoing research and regular monitoring of dive sites will be crucial to understand the long-term impacts of increased diving activity and to inform adaptive management strategies.

The future of diving trails in Hungary is intrinsically linked to the broader challenges of sustainable tourism and environmental conservation. By addressing these challenges proactively and creatively, Hungary has the opportunity to become a leading destination for freshwater diving in Europe.

As climate change and other environmental pressures continue to impact marine ecosystems globally, the importance of freshwater diving experiences may well increase. Hungary, with its abundant freshwater resources and growing expertise in underwater trail development, is well-positioned to meet this potential demand.

The conclusion is that the future of diving trails in Hungary is bright, but it requires concerted effort, innovation, and collaboration among all stakeholders - from policymakers and dive operators to local communities and individual divers. By building on the findings and recommendations of this study, Hungary can create a model for sustainable freshwater dive tourism that balances economic development, environmental conservation, and unforgettable underwater experiences. The journey ahead is as exciting as the depths we've explored, and the potential for Hungary to make a splash in the world of diving tourism is immense.

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9. Appendices

9.1. Transcriptions of Interviews with Experts

9.1.1 Interview with Károly Halász, PADI Master Scuba Diver Trainer

(This interview was done in Hungarian, and the transcript was translated to English)

Name: Halász Károly

Birthday: 1965. 03.07.

Highest Diving Certification: Padi master scuba diver trainer

Number of Dives: 8000+

QUESTION: Do you know of any international man-made sites, such as artificial reefs or underwater artworks? If so, have you dived at such a site?

RESPONSE: Yes, in Florida there is the John Pennekamp National Park, there is a statue of Christ laid down there, which is a replica of a statue in Italy called "Il Cristo degli

Abissi". There are shipwrecks that were sunk on purpose in Malta - for example - they serve as artificial reefs and have an ecological function.

All shipwrecks are very quickly populated by fish and corals, because they need the iron that dissolves from them. There is little iron in seawater and these animals need it very much, so they populate it terribly quickly, which is why they don't remove or sink shipwrecks by obviously cleaning them, cleaning them and sinking the iron structure itself.

An example of a sunken wreck in fresh water is a boat in Dorog. These have an ecosystem service function because they serve as hiding places for many predatory fish. Pike were found a lot in these places.

QUESTION: Were you involved in the construction of the dive site, the placement of underwater elements, the cleaning of the site? If so, what challenges have you faced?

ANSWER: I have not been involved only seen it. In Raja Ampat (A divesite in Indonesia) there is a coral rehabilitation section where they put plastic grids under the water and put small coral initiatives on them and then monitor the continued growth of these corals. It's a pretty good rehabilitation method, and they do it on the Great Barrier Reef in Australia. After a while - obviously it's many years - you can rehabilitate the dive sites beautifully.

I go every year to clean dive sites, mainly in Dorog, but I have also done it in Egypt. In Marsa Nakari there is a beautiful diving base but unfortunately the open water side is not protected, so the plastic rubbish coming in from the open water gets stuck in the bay. What they do here is that on the last day of the week, when there is no diving, they offer tourists the chance to pick up plastic rubbish and then they get an extra dive as a gift.

QUESTION: Where have you dived in Hungary and what are the main attractions? Is there a tourism potential of the quarries?

ANSWER: I have dived all the dive sites worth mentioning in Hungary. Unfortunately, there are not many dive sites in Hungary because there is no coastline. I have dived a lot in caves in the nineties and the thermal caves in Hungary have been dived a lot, to

mention a few: the Rákóczi cave (Bódvarákó) Aggtelek, Hévíz, Tapolca and the caves in Budapest, like the Molnár János cave.

Among the quarry lakes I have dived in many, it is important to highlight the Palatinus Lake in Dorog, which belongs to the suburb of Esztergom, and there is also the Omsk Lake, the Gyékényes quarry lake, the quarry lake in Csepel.

QUESTION: Are the dive sites in Hungary suitable for training and diving exams? If they are not suitable for a particular exam, why not?

ANSWER: The whole range of diver training can be done, except for deep diving, we don't have such deep lakes, and in caves you can't do beginner diving courses, only indoor diving courses. However, it is possible to do a DPV course and we have the equipment for that.

QUESTION: In your opinion, how could current and future dive sites in Hungary be improved? What advice would you give to planners, operators, local communities?

RESPONSE: Well, it would be very important to produce water cleanliness, because otherwise it is not a very big cost, we should clean the domestic mine members from contamination. If that is done, then there would be more visibility, then you could plan a lot more and better dives in those locations. Dredging is a good way to do this, or various chemical cleaning methods such as lime hydrate properly dosed, ecological cleaning systems can be built, the artificial reefs themselves can also perform a cleaning function, as the organisms that have settled there bind the contaminants. Generally speaking, the Hungarian quarry lakes are polluted and there is a lot of rubbish. Where there is sufficient visibility to do so, their attractiveness could be improved by the placement of more wrecks.

If you want to use the mine for diving as a primary purpose, you need to deepen and do the ecological screening. The pond should be surrounded by a stone boulder zone and reeds. Then, once the water is cleaned, care must be taken to maintain the ecosystem and natural biological balance. Then, where there is sufficient visibility to do so, their attractiveness could be improved by the placement of additional debris. These should provide shelter and a home for wildlife, without releasing any toxic substances in the long term. In the case of a vehicle, it should be sandblasted and the

engine removed. What we call a work of art is an eternal question, but it is also possible to dispose of such things by removing contaminants, for example, in Dorog there is a computer desk with a skeleton, or in Hegyeshalom a complete old-style retro telephone box is sunk. There is an underwater museum in Hungary at the moment, I was there a long time ago, I don't know if it is still in operation.

As a dive site operator, you need to create an environmentally friendly dive centre. It should be built so that divers can change in clean conditions. In Hungary, because of the continental climate, I recommend heating in winter, because the lakes are much cleaner in winter, so it is also a good time to dive. If the lake freezes over on rare occasions, that's all very well, because then it really is crystal clear and suitable for diving, but the infrastructure for this should be built: heated rooms where you can change, perhaps a sauna, or a toilet, washroom and shower.

There is business potential for equipment hire or bottle filling in such a location. Most young people today do not buy their own diving equipment, they can rent a complete set of equipment for four to five thousand forints a day, which can generate income for the operator. There is a current example of this, where equipment can be rented at the Palatinus diving centre in Dorog.

It would also be worthwhile organising diving trips to Hungary, by the way, but at the moment I only organise exams at local sites. There is potential for such diving because there are places that are easy and good to dive, warm in winter, with very beautiful vegetation and rich fauna. One such place is the Shining Spring in Tata.

9.1.2 Interview with Dr. Tamás Bardócz, Water Tourism Expert

1. Tourism and Conservation in Freshwater Environments

How do you see the balance between promoting tourism in freshwater ecosystems and maintaining their ecological health?

Preservation always should be an integral part of tourism promotion of freshwater ecosystems. The main touristic value of these ecosystems can be lost without preservation therefore the whole destination management and marketing should be based on protection of environmental values.

Can you share successful examples where tourism and conservation coexist in freshwater environments?

Angling tourism on Lake Tisza, can be a good example. Limitations on vessel sizes and engine power of fishing boats, local angling rules, restricted areas all support the preservation of nature and improve fish populations which also important for sportfishers.

What are the long-term impacts of freshwater tourism on local biodiversity, and how can they be mitigated?

Freshwater ecosystems are very complex with very different habitats. Littoral ecosystems of water plants and nesting birds are affected by the disturbance of visitors, while underwater ecosystems can be degraded by the increasing traffic of large motorboats, jetskys and wakeboard vessels. The limitation of visitors and especially the transport methods within the ecosystem is a key to mitigate the impacts. Education of visitors to protect the visited area is also very important.

How do tourism regulations differ between countries you've worked in, and what lessons can be applied universally to freshwater ecosystems?

Some countries have more focus on rules and restrictions (Hungary) while more efforts on training of visitors and local people, I believe can have more significant impact.

How can the tourism industry play a role in educating the public about freshwater conservation?

There are much more room for improvement on this field. Social media could provide an excellent channel to reach potential visitors and educate them.

What unique challenges do freshwater ecosystems face compared to marine environments in balancing tourism and conservation?

Freshwater ecosystems are usually more vulnerable and impacted more by human activities. These ecosystems does not have the large buffer capacity of offshore regions linked to most marine coastal ecosystem.

2. Importance of Freshwater Ecosystems

Could you elaborate on the critical ecological roles that freshwater ecosystems play globally?

There are many ecosystem services provided by the freshwater ecosystems including natural and constructed wetlands. These services are classified in the Common International Classification of Ecosystem Services (CICES) as Provisioning (e.g. provide fish), Regulating and Maintenance (carbon sequestration) and Cultural (tourism, landscape etc.) services.

From your international perspective, which freshwater species or habitats are most at risk, and what are the most pressing conservation issues?

I think, the biggest threat on freshwater ecosystems is the climate change and especially the warmer temperature and longer drought periods in the Carpathian Basin. This will led to huge loss of surface waters, increasing eutrophication and succession of the remaining freshwaters.

How does freshwater biodiversity loss impact larger environmental systems, and how can this be communicated to a broader audience?

Wetland habitats provide feeding and resting grounds for many migrating bird species. Further reduction of these habitats can cause degradation of these populations.

In your experience, how are different countries addressing the preservation of their freshwater ecosystems? Are there any particularly innovative approaches?

In many countries, the retention of water is getting more and more important. There are many Horizon Europe projects aimed to restore and preserve freshwater habitats: https://restore4life.eu/

Can aquaculture coexist with conservation efforts in freshwater environments, and if so, what best practices have you seen work internationally?

Extensive pond aquaculture to produce carps and predatory fish creates wetland ecosystems which provide ecosystem services like natural wetlands. Intensive aquaculture combined with wetlands of fish ponds to reuse the discharged water.

3. Challenges and Opportunities in Freshwater Tourism

What are the biggest challenges freshwater ecosystems face due to tourism, particularly in regions with high biodiversity?

Uncontrolled tourism can be a big challenge for freshwater ecosystems. Engine powered water sports, buildings and constructions in the littoral region are the biggest threats. Next to the water investments are very attractive for investors, but these investments destroy the most vulnerable parts of the ecosystem (e.g. Lake Balaton)

Could you discuss any innovative freshwater tourism initiatives that also support local conservation efforts?

Angling tourism management of Lake Tisza also protects the spawning and wintering areas of the artificial wetland system.

How can countries with abundant freshwater resources leverage them for sustainable tourism while protecting sensitive environments?

Sustainable transport of visitors and education of visitors and locals.

What role does infrastructure play in freshwater tourism, and how can it be developed sustainably?

Infrastructure defines the main flows of visitors to avoid mass use of sensitive areas. Infrastructure design is a key element to protect the vulnerable areas.

What potential do you see for eco-friendly activities like diving in freshwater environments as a way to promote both tourism and conservation?

There is a great potential to use social media to improve the eco-friendly activities. Visitor numbers and activities should be strictly controlled even in case of these activities.

4. Conservation Strategies in Freshwater Environments

What conservation strategies have been most successful in protecting freshwater environments in the regions where you have worked?

Natura 2000 protection approach seems very successful. It allows economic activities which is inline with the conservation goals.

How can local communities be involved in freshwater conservation, particularly in areas where tourism is growing?

It is very important, that the local communities must be involved in tourism. The tourism must be integrated in the local economy and decision making should be done on the local level.

How do international policies on freshwater conservation differ, and what best practices could be standardized globally?

There are no big differences in freshwater ecosystem conservation in Europe because the main tool of this is the Natura 2000 network. In Africa the ecosystem approach for aquaculture development is a key element to protect Lake Victoria.

Can you discuss the role of technology in monitoring and conserving freshwater ecosystems?

Freshwater ecosystem degradation caused by climate change can be reduced by dredging, water management, habitat restoration. The planning and implementation of these need new technologies like real-time water quality data, big data analysis, satellite image analysis.

In your opinion, what is the most overlooked aspect of freshwater conservation, and how can it be addressed?

The risk caused by invasive species is much higher in a changing climate. Some species can speed up the degradation of ecosystems and these populations should be controlled.

· What advice would you give to policymakers aiming to integrate tourism into freshwater conservation strategies effectively?

Always involve the local communities in the planning and management of tourism.

· How can freshwater diving experiences contribute to a deeper public understanding of conservation needs?

Survey of underwater habitats and fish populations using citizen science methods should be better used in freshwater ecosystems.

9.2. Data extracted from divecenter.hu

Név	Jelleg	Aljzat	Roncs	Geometria	Visszajelzes	Ertekeles (1-5)	Nehezseg (1-3)	Melyseg (m)	Latotav	Aramlas
Balaton, Tihany, Széchenyi gát	szétterülő	homokos, sziklás	Nincs	Pontos kordináta	1/1 db	3.0	2	3	0-4m	Nincs
Csepel	szétterülő	homokos	Nincs	Jó közelítésű kordináta	2/2 db	1.0	2	6	0-4m	Nincs
Diósdi Sportcsarnok tüzivíztározó	mesterséges fal	kavicsos	Nincs	Pontos kordináta	1/1 db	4.0	2	4	4-10m	Nincs
Dobai Kút	fal	homokos	Nincs	Tájékoztató kordináta	1/1 db	3.0	3	12	0-4m	Nincs
Dunaharaszti, Vizisí Tó	szétterülő	homokos	Nincs	Tájékoztató kordináta	1/1 db	1.0	2	5	0-4m	Nincs
Ecséd	szétterülő	homokos	Nincs	Tájékoztató kordináta	6/6 db	4.0	2	25	0-4m	Nincs
Erdőkertesi Octopus Horgász- és Búvártó	szétterülő	homokos	roncs, (teljes roncs)	Tájékoztató kordináta	2/2 db	4.0	2	7	0-4m	Nincs
Fényes Forrás	fal	homokos	Nincs	Pontos kordináta	6/10 db	4.6	2	5	0-4m	Van
Gyáli tó	szétterülő	homokos	roncs, (rakomány)	Tájékoztató kordináta	2/2 db	4.0	2	9	0-4m	Nincs
Gyékényes	szétterülő	homokos	roncs, (rakomány)	Jó közelítésű kordináta	6/9 db	3.3	2	13	4-10m	Nincs
Hegyeshalom, Futószalag Roncs	szétterülő	homokos	roncs, (csak váz)	Pontos kordináta	4/5 db	3.8	2	35	4-10m	Nincs
Hegyeshalom, Leo Helye	szétterülő	homokos	Nincs	Pontos kordináta	1/2 db	2.0	2	23	0-4m	Nincs
Héviz Springcave (forrásbarlang)	barlang	homokos	Nincs	Pontos kordináta	1/1 db	4.0	3	42	10-25m	Van
Kőbánya, kerti kút	mesterséges barlang	mesterséges	Nincs	Pontos kordináta	2/4 db	4.5	3	35	25m felett	Nincs
Kőbánya, nagyterem	mesterséges barlang	mesterséges	Nincs	Pontos kordináta	1/2 db	4.5	2	28	10-25m	Nincs
Lupa, Budakalász	szétterülő	homokos	Nincs	Tájékoztató kordináta	2/2 db	1.0	3	7	0-4m	Nincs
Molnár János Cave (barlang)	barlang	sziklás	Nincs	Pontos kordináta	5/5 db	5.0	3	36	25m felett	Nincs
Nagyteveli víztározó	mesterséges fal	homokos	Nincs	Jó közelítésű kordináta	1/1 db	1.0	1	7	0-4m	Nincs
Nyékládháza - Nádas	szétterülő	homokos	Nincs	Tájékoztató kordináta	1/2 db	4.5	2	11	0-4m	Nincs
Ócsai tó	mesterséges fal	kavicsos	Nincs	Jó közelítésű kordináta	2/4 db	3.5	2	30	4-10m	Nincs
Öböl Beach Búvárcentrum	szétterülő	homokos	roncs, (teljes roncs)	Pontos kordináta	1/1 db	4.0	1	6	0-4m	Nincs
Palatinus-tó Búvárbázis, Dorog	szétterülő	homokos	Nincs	Jó közelítésű kordináta	6/16 db	3.4	2	12	0-4m	Nincs
Palatinus-tó, Dorog Kis öböl	szétterülő	homokos	Nincs	Pontos kordináta	2/5 db	2.6	2	10	0-4m	Nincs
Pilismaróti Öböl	szétterülő	homokos	Nincs	Jó közelítésű kordináta	3/4 db	1.5	1	6	0-4m	Nincs
Szalki Tavak	szétterülő	kavicsos	Nincs	Jó közelítésű kordináta	4/7 db	3.0	2	7	0-4m	Nincs
Vadnapark	szétterülő	kavicsos	Nincs	Jó közelítésű kordináta	1/2 db	3.5	1	22	4-10m	Nincs

Explanation: This is the data I have extracted from the forum divecenter.hu to help with the assessment of the divesites found within Hungary

9.3. Plans and Layouts

Legend

- Building
- Sand
- Grass
- Wooden deck
- Dirt road
- Reed
- Water
- Tree
- 50 cm contour lines

North

Border of the landplots

Storage room

Compressor room

Base building

Volleyball courts

Parking area (on grass)

Pier

Outline of the diving trail

Entrance

MAGYAR AGRÁR- ÉS ÉLETTUDOMÁNYI EGYETEM Tájépítészeti, Településtervezési és Díszkertészeti Intézet	Title of the Thesis: Underwater Trails: Balancing Tourism and Conservation in Freshwater Conditions	Plan number: 01
	Student: Tamás Áron Klenczner	Title of the plan: Current Structure of the Diving Centre at Lake Palatinus
	Consultants: Ildikó Módosné Bugyi, Dr. László Kollányi	
	Head of department: Dr. István Valánszki	
Department of Landscape Protection and Reclamation	Director: Dr. Fekete Albert Specialisation manager: Dr. Jombach Sándor	Date: 2024. 10. 30.
	Email address: tamas@klenczner.com	Scale: 1:1000
Hungary, 1118 Budapest, Villányi út 29-43.	Institute website: https://landscape.uni-mate.hu/ Email address: tajepiteszet@uni-mate.hu	
	Sources of the base data used for the mapping process: https://geoshop.hu/	

Legend

- Building
- Sand
- Grass
- Wooden deck
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- Water
- Tree
- 50 cm contour lines

Border of the landplots

Storage room

Compressor room

Base building

Volleyball courts

Parking area (on grass)

A1

A2

F1

F2

F3

F4

F5

F6

E1

E2

E3

Pier

Outline of the diving trail

Entrance

North

Conflicts

Ecological Conflict

E1 – Soil degeadation due to parking

E2 – Lack of trees in the parking area

E3 – The state of the existing reeds

Functional Conflict

F1 – The Lack of Changing Facilities.

F2 – Lack of distinction between pedestrian and vehicle trafic

F3 – Underused Volleyball courts

F4 – Lack of equipment preparation space

F5 – Lack of services for Non-diving visitors

F6 –The state of the wooden deck

Aesthetic Conflicts

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Tájépítészeti, Településtervezési és Díszkertészeti Intézet

Department of Landscape Protection and Reclamation

Hungary,
1118 Budapest,
Villányi út 29-43.

Title of the Thesis: Underwater Trails: Balancing Tourism and Conservation in Freshwater Conditions

Student: Tamás Áron Klenczner

Consultants: Ildikó Módosné Bugyi, Dr. László Kollányi

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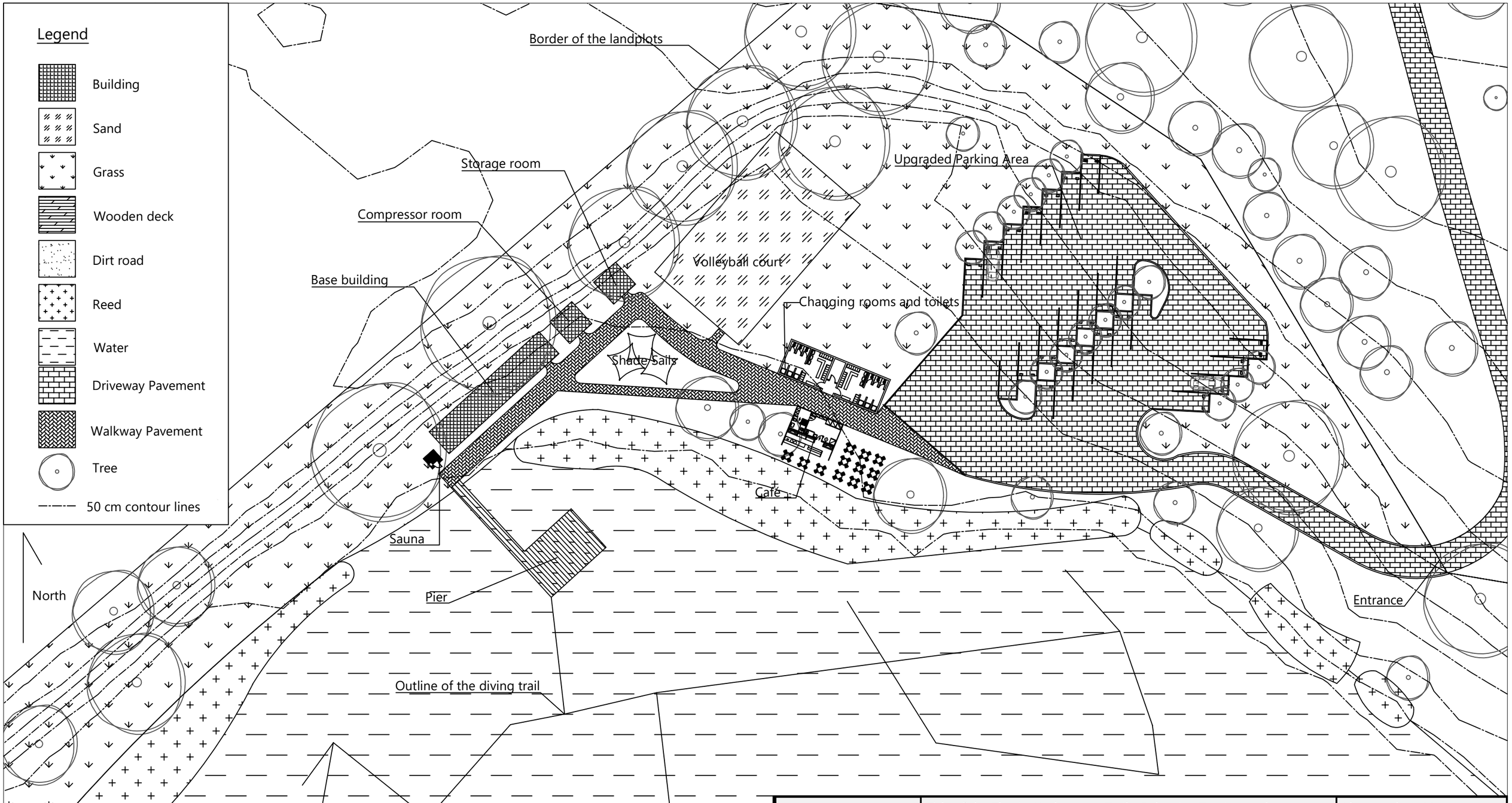
Sources of the base data used for the mapping process:
https://geoshop.hu/
https://archweb.it/

Plan number: 03

Title of the plan: Land Use Conflicts of the Diving Centre at Lake Palatinus

Date: 2024. 10. 30.

Scale: 1:1000



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Director: Dr. Fekete Albert Specialisation manager: Dr. Jombach Sándor

Email address: tamas@klenczner.com

Institute website: https://landscape.uni-mate.hu/ Email address: tajepiteszet@uni-mate.hu

Sources of the base data used for the mapping process:
https://geoshop.hu/
https://archweb.it/

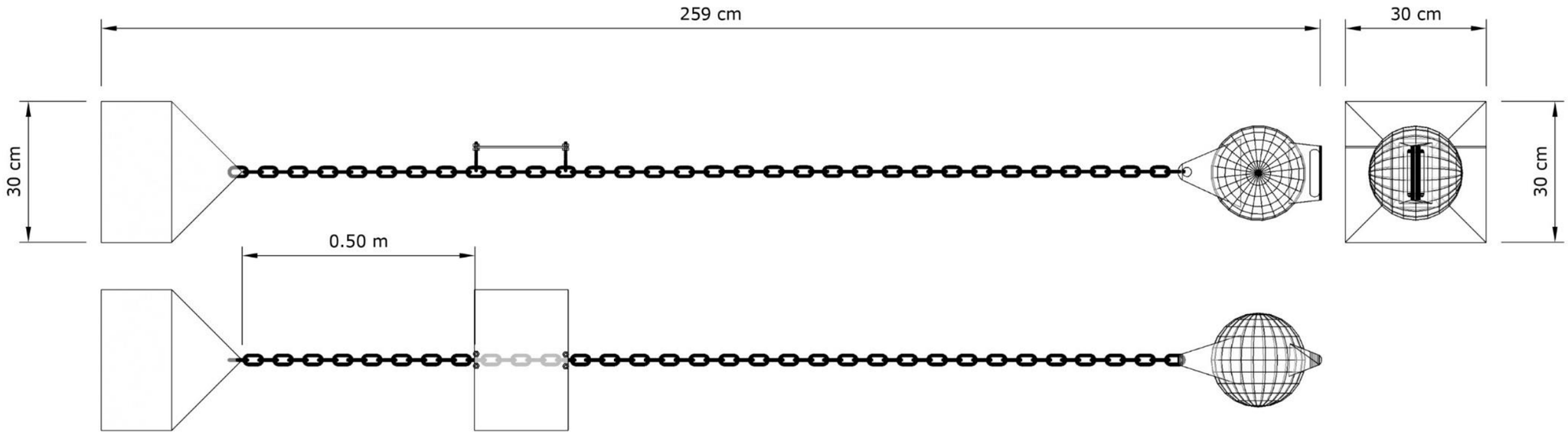
Plan number: 02

Title of the plan: Proposed Structure of the Diving Centre at Lake Palatinus

Date: 2024. 10. 30.

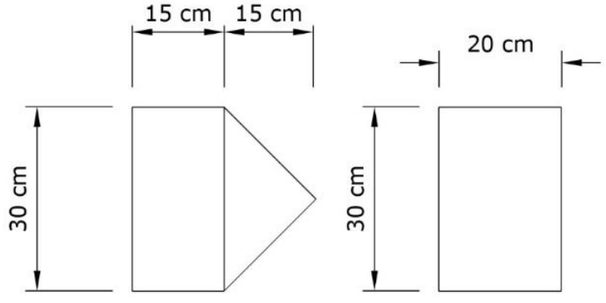
Scale: 1:1000

THE WHOLE UNDERWATER SIGN



INDIVIDUAL PARTS

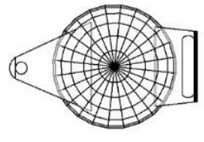
CONRETE SINKERS
30 cm X 30 cm



STAINLESS STEEL INFOBOARD
30 cm X 20 cm

2X 7.5 mm U-BOLT

PLASTIC ROUJND BUOY 20 cm



2 METER STAINLESS STEEL CHAIN

200 cm

MAGYAR AGRÁR- ÉS ÉLETTUDOMÁNYI EGYETEM
Tájépítészeti, Településtervezési és Díszkertészeti Intézet

Department of Landscape Protection and Reclamation

Hungary,
1118 Budapest,
Villányi út 29-43.

Title of the Thesis: Underwater Trails: Balancing Tourism and Conservation in Freshwater Conditions	Plan number: 04
Student: Tamás Áron Klenczner	Title of the plan: An underwater sign and its structure
Consultants: Ildikó Módosné Bugyi, Dr. László Kollányi	
Head of department: Dr. István Valánszki	
Director: Dr. Fekete Albert Specialisation manager: Dr. Jombach Sándor	Date: 2024. 10. 30.
Email address: tamas@klenczner.com	Scale: Varies
Institute website: https://landscape.uni-mate.hu/ Email address: tajepiteszet@uni-mate.hu	
Sources of the base data used for the mapping process: -	

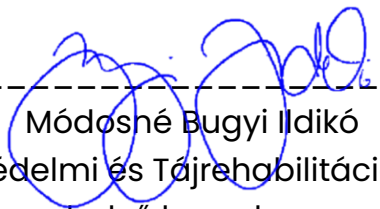
NYILATKOZAT

Klenczner Tamás (Neptun azonosítója: IDTGJO) konzulenseként nyilatkozom arról, hogy a diplomadolgozatot áttekintettem, a hallgatót az irodalmi források korrekt kezelésének követelményeiről, jogi és etikai szabályairól tájékoztattam.

A diplomadolgozatot a záróvizsgán történő védésre **javaslom / nem javaslom**.

A dolgozat állam- vagy szolgálati titkot tartalmaz: igen nem*

Kelt: Budapest, 2024. november 2.



Módosné Bugyi Ildikó
MATE Tájvédelmi és Tájrehabilitációs Tanszék
belső konzulens

NYILATKOZAT

Klenczner Tamás Áron (hallgató Neptun azonosítója: IDTGJO) konzulenseként nyilatkozom arról, hogy a záródolgozatot/szakdolgozatot/diplomadolgozatot/portfóliót[1] áttekintettem, a hallgatót az irodalmi források korrekt kezelésének követelményeiről, jogi és etikai szabályairól tájékoztattam.

A záródolgozatot/szakdolgozatot/diplomadolgozatot/portfóliót a záróvizsgán történő védésre **javaslom / nem javaslom**[2].

A dolgozat állam- vagy szolgálati titkot tartalmaz: igen nem*[3]

Kelt: Budapest 2024 év november hó 04 nap

_____

belső konzulens

[1] A megfelelő dolgozattípus meghagyása mellett a többi típus törlendő.
[2] A megfelelő aláhúzandó.
[3] A megfelelő aláhúzandó.