Getting Started in Cavern Diving

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## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>2</td>
</tr>
<tr>
<td>1. Cavern Diving Safety and Training Limits</td>
<td>3</td>
</tr>
<tr>
<td>Accident Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Cavern Diver Training Limits</td>
<td>6</td>
</tr>
<tr>
<td>2. The Cave Environment</td>
<td>9</td>
</tr>
<tr>
<td>Landowner Relations</td>
<td>9</td>
</tr>
<tr>
<td>Cavern and Cave Conservation</td>
<td>10</td>
</tr>
<tr>
<td>Cave Type and Formation</td>
<td>11</td>
</tr>
<tr>
<td>The Hazards of the Cave Environment</td>
<td>16</td>
</tr>
<tr>
<td>3. Cavern Diving Equipment</td>
<td>18</td>
</tr>
<tr>
<td>Equipment Goals and Objectives</td>
<td>18</td>
</tr>
<tr>
<td>Configuration Overview</td>
<td>18</td>
</tr>
<tr>
<td>Mask and Fin Modifications</td>
<td>20</td>
</tr>
<tr>
<td>Gas Delivery Equipment</td>
<td>20</td>
</tr>
<tr>
<td>Guidelines and Reels</td>
<td>23</td>
</tr>
<tr>
<td>Lights for Cavern Diving</td>
<td>24</td>
</tr>
<tr>
<td>Attachment Hardware</td>
<td>24</td>
</tr>
<tr>
<td>Knives and Cutting Tools</td>
<td>26</td>
</tr>
<tr>
<td>Instrumentation</td>
<td>26</td>
</tr>
<tr>
<td>Proper Weighting for Cavern Diving</td>
<td>27</td>
</tr>
<tr>
<td>4. Cavern Diving Techniques/Procedures</td>
<td>29</td>
</tr>
<tr>
<td>Propulsion Techniques</td>
<td>29</td>
</tr>
<tr>
<td>Guideline and Reel Use</td>
<td>29</td>
</tr>
<tr>
<td>Dive Planning</td>
<td>30</td>
</tr>
<tr>
<td>When to “Call” the Dive</td>
<td>32</td>
</tr>
<tr>
<td>5. Communication</td>
<td>32</td>
</tr>
<tr>
<td>Command Signals</td>
<td>32</td>
</tr>
<tr>
<td>Light Signals</td>
<td>33</td>
</tr>
<tr>
<td>Hand Signals</td>
<td>34</td>
</tr>
<tr>
<td>Touch-Contact</td>
<td>35</td>
</tr>
<tr>
<td>6. Stress Management</td>
<td>36</td>
</tr>
<tr>
<td>7. Emergency Procedures</td>
<td>36</td>
</tr>
</tbody>
</table>
Introduction

This book covers the key academic information you need to master as part of your NSS-CDS Cavern Diver course. It is designed to be used in conjunction with the Cavern Diver Course Study Guide workbook. Together, these two items will help prepare you to successfully complete the Cavern Diver Course Final exam. To use them, you should:

- Begin by reading this book in its entirety.
- Using this book as a reference, go through the Study Guide, filling in the blanks you will find there with the word or words that best complete the statements it contains. This book and the Study Guide cover the same information, in the same order. In most instances, there is a word-for-word match between the statements you will find in the Study Guide, and information you will find in this book.

If, while reading this book or completing the Study Guide, you have questions or come across information you do not understand, make a note of it. Ask your Cavern Diver Instructor to clarify this information at the start of the course.

**WARNING**

Cavern and cave diving are extremely hazardous activities requiring specialized training and equipment. Although having the right equipment, obtaining the necessary training and following the proper procedures cannot eliminate the risk of equipment loss or damage, serious personal injury or death, not having these items increases your risk factors exponentially. **Do not attempt to cave or cavern dive without the proper training or equipment.** This book, by itself, is not adequate substitute for these items.
1. Cavern Diver Safety and Training Limits

To START, let’s examine the closely related issues of safety and the limits of Cavern Diver training.

**Accident Analysis**
Cavern Diver training is, to a large degree, designed to help you avoid the mistakes that cause divers to die in caverns and caves. One way in which we do this is to identify what these mistakes are, as well as the actions that help divers avoid them.

A careful analysis of the more than 350 diver fatalities occurring in North and Central American caverns and caves over the past 50 years reveals that virtually every such fatality is attributable to three direct causes. These are:

- **Failure to run a continuous guideline to open water**—Underwater caverns and caves are generally not comprised of a single, easy-to-follow conduit. Instead, they are often a maze of interconnecting tunnels (see Figure 1). Seldom does the way out resemble the way in. Additionally, the presence of an easily disturbed layer of silt can—in just a matter of seconds—obliterate the visibility that might otherwise make it easy to see which way leads to the exit. Having a continuous guideline to the cavern or cave entrance helps ensure that divers will be able to find their way out, regardless of the complexity of the cavern or cave, or loss of visibili-

**Figure 1**: The desire to prevent fatalities underlies much of what we teach in Cavern and Cave Diver training.
In many underwater cavern and cave fatalities, the victims had sufficient breathing gas to exit from their maximum point of penetration; however, lack of a continuous guideline prevented them from finding that exit before their gas supply ran out.

Figure 2: The maze-like configuration of most underwater caverns and caves makes having a continuous guideline essential.

Failure to keep at least two thirds of each diver’s starting gas supply in reserve to exit the cavern or cave—In several instances in which the victims may have otherwise been able to find their way out of the cavern or cave, they ran out of breathing gas before doing so. Open-water diving often conditions divers to not think about surfacing until their pressure gauges reach 1,000 psi or less. Obviously, if divers consume 2,000 psi (or more) while reaching a certain point in a cavern or cave, the 1,000 psi (or less) remaining will not be sufficient to get them out. Even when divers save fully half their breathing gas to exit, they may discover that factors such as loss of visibility or momentary disorientation causes them to use more gas while exiting that while entering. Experience shows us that, to have sufficient breathing gas to exit a cavern or cave without running out, divers must keep at least two thirds of their starting gas supply in reserve.
Exceeding the safe operational limits of the breathing media used—This chiefly involves diving below 130 feet on air, where factors such as nitrogen narcosis, carbon dioxide build-up, oxygen toxicity and rapid breathing gas consumption can all contribute to diver fatalities. Additional cave diver fatalities are attributable to oxygen toxicity resulting from exceeding a particular Nitrox mixture’s Maximum Operating Depth (MOD), and hypoxia resulting from exceeding a particular Trimix mixture’s safe operating ceiling.

While virtually every cavern or cave diving fatality results from one or more of these three direct causes, there are also two contributing causes worth noting. These are factors that—while not immediately responsible for diver deaths—play such a large role in so many cavern and cave diving fatalities, they deserve mention. These two contributing causes are:

Lack of necessary Cave or Cavern Diver training or exceeding the limits of training—Believe it or not, over 90 percent of the divers who perish in underwater caverns or caves have no formal training in cave or cavern diving. Obviously, divers who lack this training may not possess the knowledge, experience and skills necessary to avoid the three direct causes of cavern and cave diver fatalities. In instances where fatalities involve certified Cavern or Cave Divers, a contributing factor has often been that divers exceeded the limits level of training they possessed (i.e., Cavern Divers venturing beyond the light zone, Intro-to-Cave Divers making dives involving complex navigation, etc.).

Failure to carry or use at least three sources of light—Dive lights are among the most failure-prone of all dive equipment. Loss of light means loss of visibility. A contributing factor in the death of many divers who lack formal Cavern or Cave Diver training has been failure to carry an adequate number or lights. Trained Cavern and Cave Divers know that, to
prepare adequately for potential light failure, they must have at least three sources of light per person. Cave divers carry at least one primary and two back-up lights; Cavern Divers carry at least one primary and one back-up light (because Cavern Divers remain within sight of daylight, the sun counts as the third source of light).

By restating the three direct and two contributing causes of cavern and cave diver fatalities as procedures to be followed, we have what are called the **Five Rules of Accident Analysis**. There are:

1. Be **trained** and certified for cavern or cave diving, and remain well within the limits of your training and experience.

2. Maintain a continuous **guideline** leading to the cavern or cave entrance.

3. Remain within the safe operational (**depth**) limits of your breathing media.

4. Keep at least two-thirds of your starting gas supply (**air**) in reserve to exit the cave.

5. Have at least three sources of **light** per diver.

Here is one way many divers remember the five rules:

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**Figure 4:** Acronym for remembering the five Rules of Accident Analysis

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While neither cavern nor cave diving can ever be made “perfectly safe” (such diving will always present substantially more risk than is present when diving in open water), it is interesting to note that, for all intents and purposes, **no diver who has remained well within the Five Rules of Accident Analysis has ever perished in a cavern or cave.**

**Cavern Diver Training Limits**

The Cavern Diver course does not, by itself, comprise a complete course in how to explore underwater caverns and caves. It is, in fact, the first step in a four-part process leading for full Cave Diver certification. The additional steps in this process are:

- **Intro to Cave Diver**—The next step past Cavern Diver, this course focuses on the skills required to explore caves beyond sight of the entrance, while remaining within fairly restrictive limits. These limits include stay-
ing within the no-decompression limits and linear navigation along a single, continuous guideline. Intro-to-Cave Divers who are not under direct instructor supervision are also limited to diving single tanks.

Apprentice Cave Diver—Here we introduce divers to skills such as: the use of double cylinders (if this did not take place during Intro to Cave Diver training); more complex cave navigation, including jumps and gaps; and, if students choose to do so, decompression diving.

(Full) Cave Diver—The final step in beginning Cave Diver training, this is where divers acquire any knowledge and skills not previously covered in the Apprentice Cave Diver course.

Each of these steps requires at least two days of training and four dives.

Figure 5: The steps leading to full NSS-CDS Cave Diver certification

Some divers choose to limit their training solely to the Cavern Diver level, in as much as they have no desire to ever explore underwater caves beyond direct site of the entrance. Other divers enroll in Cavern Diver as a means of qualifying to take part in higher levels of Cave Diver training. Still others who take the Cavern Diver course have little intention of diving actively in caverns or caves; they are simply in search of beneficial knowledge and skills they can apply to other diving activities.

Whatever your goals and objectives in taking the Cavern Diver course, or other levels of NSS-CDS diver training, it is important that you be aware of and remain within the limits of that training. Remember that failure to remain within the limits of training and experience has been a contributing cause in several diver fatalities. The limits of NSS-CDS Cavern Diver training include:
□ Remaining within direct sight of the entrance.
□ Penetration of no more than 130 feet/40m from the surface.
□ A maximum depth of 70 feet/21m.
□ Minimum starting visibility of 40 feet/13m.
□ Not passing through restrictions.
□ Not exceeding the no-decompression limits.

These limits will appear on your NSS-CDS Cavern Diver certification card.

Figure 7: The limits of Cavern Diver training include remaining within direct sight of the cavern entrance and never venturing more than 130 feet/40m from the surface

In addition to remaining within the limits of your own training and experience, you must also remember that the limits of any cavern or cave dive are determined by the training and experience level of the least qualified team member. This means that, just because you are a certified Cavern Diver, you should not take friends who lack this training into a cavern with you. Similarly, you should not accompany divers trained to the Intro-to-Cave level, or above, on dives that exceed the Cavern Diver limits outlined earlier.
2. The Cave Environment

Here we address:

- Landowner Relations
- Cavern and Cave Conservation
- Cave Type and Formation
- The Hazards of the Cave Environment

Landowner Relations

In terms of your relationship with the individuals, organizations and government entities that either own the land on which the caverns and caves you dive are located, or own the land that provides access to these sites, there are two important points to bear in mind. These are:

- **There is no un-owned land; never dive a site without permission**—There is an understandable temptation to assume that land which is undeveloped, unfenced and unposted “doesn’t really belong to anyone.” It does—and regardless of whether the owner is an individual, business or organization, or a government agency, it is the owner that has the right to determine who has access to the property and what may occur there. Before diving any cavern or cave site, determine who the owner is and whether you need express permission to dive there.

- **It is important cavern and cave divers always follow whatever rules are in effect at any site**—Most popular underwater caverns and caves are located in government controlled or privately operated parks and recreation sites. Such sites typically have and enforce various sets of rules applying to divers of different training and experience levels. For example: Divers certified to the Apprentice Cave Diver level and above may use double cylinders; divers certified to the Intro-to-Cave Diver level and below may not. It is important you learn what rules are in effect at the sites you dive and follow them. Your willingness to follow such rules will not only affect whether you may return to the site in the future, but whether other cavern and cave divers may do so as well.

A rule you will find in effect at Florida’s state parks and recreation areas, as well as at many privately operated sites, is the **No Lights Rule**. Designed to help prevent fatalities among open-water divers, it prevents those who lack Cavern or Cave Diver training and certification from entering the water with dive lights. Without lights, such divers have difficulty penetrating caverns and caves far enough to get into trouble.
Circumstances may require you to explain the reason behind the No Lights Rule to open-water divers, who will naturally be curious as to why you are able to take lights with you into the water while they may not. Be sure to do so as diplomatically as possible.

![No Lights Prohibited Sign](image)

**Figure 8:** The “No Lights” rules is enforced at Florida’s state parks and many privately operated cavern diving sites

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**Cavern and Cave Conservation**

Underwater caverns and caves are fragile environments in which careless divers can all too easily cause irreparable damage. To avoid being the cause of such damage:

- **Make sure whatever site you choose to cavern dive matches your ability to dive it in as environmentally sound a manner as possible**—Let’s say, for example, that several months have passed since your last cavern dive. You realize that, as a result, your buoyancy-control skills may not be up to par. Therefore, before diving a potentially silty cavern with fragile rock formations, such as Peacock I, you decide to spend practice time in a relatively silt-free and damage-proof cavern, such as the one at Ginnie Spring. In so doing, you are taking an important step in protecting Peacock I from further harm.

- **The best propulsion technique to use in any cavern or cave is generally the one that has the least potential to cause damage**—In a large, low-flow cavern with many delicate formations, the best propulsion technique will likely be a modified flutter or frog kick. However, in a high-flow cavern with well-established hand holds, such as Devil’s Ear, it is most likely better to pull yourself along, rather than flailing your way in with your fins and, in the process, risk kicking rock formations you can’t see.
For all intents and purposes, any damage you cause to the fragile cavern/cave environment will be visible forever—Fragile stone formations and speleothems (the stalactites, stalagmites, and columns found in Mexican and Bahamian caverns and caves) take tens of thousands of years to form. They cannot grow back once damaged. Even something as seemingly innocuous as a hand or fin print in a bed of clay can remain visible beyond our lifetimes. They only possible way to deal with such damage is to prevent it.

Cave Type and Formation

There are four basic types of underwater caverns and caves. These are:

- Coral caves—These typically form with the tops of adjacent coral reefs grow together, forming tunnels and arches. They are common along the edges of walls and drop-offs. Coral caves generally admit sunlight through multiple openings and are not particularly extensive. It is unusual for one to pose a substantial threat to diver safety.

- Sea caves—Formed by wave action eroding limestone or other soft rock, sea caves generally tend to penetrate the cliffs in which they form only a short distance. During all but the highest tides, most sea caves are open to air at the top.

- Lava tubes—A by-product of volcanic eruptions, lava tubes form when the outside of a lava flow cools and hardens, while the interior remains molten. If the lava flow abruptly terminates, the molten core may empty out, leaving a hollow conduit. Divers are most likely to find underwater lava tubes in Hawai’i and, to a lesser degree, the Pacific northwest.

- Dissolution caves—These form when the carbonic acid present in groundwater dissolves soft rock, such as limestone or dolomite. Dissolution caves often form a series of complex, maze-like passageways.

The most widely used term used to describe the type of terrain most conducive to the formation of caverns and caves is karst. This is where dissolution caves form.

Dissolution cave systems, such as those found in north-central Florida, Mexico’s Yucatan Peninsula and the Bahamas, are also the type most frequently visited by divers. Unfortunately, due to factors such as the complex, maze-like passageway configuration of many such systems, this is the type of cave most likely to be the site of diver fatalities. For these reasons, we will spend most of this section focusing on dissolution cave formation—
particularly as it applies to the popular cavern and cave diving region of north-central Florida.

**Dissolution Cave Formation**—Beneath a thin layer of sand and clay, most of north-central Florida is nothing but layer upon layer of limestone (calcium carbonate). Limestone is a highly porous rock in general; the limestone underlying north-central Florida is especially porous. Water moves easily between the loosely compacted particles and shells that comprise most of this rock.

When rain falls on the farms and woodlands of north-central Florida, the ground absorbs it almost immediately. (This is why you see so few culverts, ditches and streams in the area.) Before disappearing under ground, however, the rainwater absorbs carbon dioxide (CO₂) from the decaying organic matter it passes through. When combined with the hydrogen and oxygen in water (H₂O), the carbon dioxide forms **carbonic acid** (H₂CO₃).

The carbonic acid present in the north-central Florida’s ground water is very dilute. It has no impact on divers or their equipment. (North-central Florida’s groundwater quality, in fact, vastly eclipses that of tap water nearly anywhere else on the planet.) Nevertheless, given a time frame of several thousand years, the carbonic can dissolve considerable limestone.

One example of this dissolution process is what we call **spongework**. This occurs when carbonic acid dissolves pockets of softer limestone, leaving rock that resembles swiss cheese.
Figure 9: The pockmarked surface of the much of north-central Florida’s underwater caves (spongework) is one example of how the carbonic acid present in ground water can dissolve the region’s soft limestone substrate.

Figures 10-13 show how, on a larger scale, this dissolution process results in the formation of extensive underwater cave systems.

Figure 10: When rain falls on north-central Florida’s highly porous karst terrain, it immediately disappears under ground, saturating the limestone below.
Figure 11: Rivers passing through the region often have water levels that are lower than the surrounding water table. Gravity creates a tendency for water to move sideways through the rock, in an effort to run downhill.

Figure 12: In its movement toward the region’s rivers, ground water seeks the path of least resistance. This can include bedding planes (the boundary between limestone layers), fractures in the rock and even interconnecting spongework. As this takes place, the carbonic acid works to further dissolve these conduits. When passage diameter exceeds nine centimeters, the rate of dissolution accelerates. Thus, the biggest conduits for water flow tend to become even bigger over time. Eventually, these can form an interconnecting maze of cave passageways.
Cavern and Cave Entrance Types—Cavern and cave entrances may be either springs or siphons. The primary difference between the two is that:

- Springs exist where water flows out of the ground.
- Siphons exist where water flows into the ground.

You already know what causes the springs to form. Siphons, on the other hand, form in one of two ways:

- A temporary reversal of spring flow caused by high water levels in adjacent rivers can create siphons.

Figure 13: Mature cave systems may surface in a spring basin, away from the river, and connected to the river by a spring run.

Figure 14: If the level of adjacent rivers rise above that of the water table, karst openings that are normally springs may temporarily siphon.
The development of sinkholes over underground rivers often creates openings with a spring on one side and a siphon on the other.

Figure 15: The downstream side of sinkholes are also siphons.

Diving springs is almost always safer than diving siphons because divers will require less time, effort and breathing gas to exit a spring than they needed to enter (the opposite is true for siphons). Additionally, divers entering siphons may experience substantially less visibility than divers entering springs.

Many of north-central Florida’s most popular cave and cavern diving sites siphon at least once a year. When this happens may vary; however, it is most likely to occur during the late winter and early spring. For this reason, it is always wise to check conditions before you begin a cavern diving trip. Current spring condition reports are available from many area dive operations, as well as from The Cave Diving Website (www.cavediving.com).

Siphons on the downstream side of sinkholes generally exist year-round. The only north-central Florida siphon regularly visited by cavern divers is the downstream side of the NSS-CDS owned Cow Spring.

**The Hazards of the Cave Environment**

The chief reason cavern and cave diving poses such a great threat to divers is the fact it places them under water, with a limited breathing gas supply, unable to make a direct ascent to the surface and facing the potential loss of light and/or visibility.

One reason cavern and cave divers may lose visibility is the disturbance of sediment.
Of all the various sediments divers may encounter in caverns and caves, sand is most easily disturbed; once disturbed, however, clay remains in suspension longest.

Figure 16: The relationships between various sediment types found in underwater caverns and caves

The presence or absence of current provides divers with the best clue as to whether or not they will encounter substantial quantities of silt in a particular cavern or cave.

Two additional hazards cavern and cave divers face are restrictions and line traps.

Restrictions are a passage or opening too narrow for divers to pass through side by side—Unless equipped with extra-long second stage hoses and trained in doing so, divers cannot pass through restrictions while sharing breathing gas. This is why passing through restrictions is not within the limits of Cavern Diver training.

Line traps are openings into which divers may accidentally pull the guideline, but which is too narrow for the divers to pass through themselves—The danger associated with allowing the guideline to pass through a potential line trap is that, should divers need to exit in limited visibility, they will not be able to follow the guideline to do so.
3. Cavern Diving Equipment

In this section, we discuss:

- Equipment Goals and Objectives
- Configuration Overview
- Mask and Fin Modifications
- Gas Delivery Equipment
- Guidelines and Reels
- Lights for Cavern Diving
- Attachment Hardware
- Knives and Cutting Tools
- Instrumentation
- Proper Weighting for Cavern Diving

Equipment Goals and Objectives

Cavern diving equipment is largely the same as that used for open-water diving—albeit with a few, very important modifications. In contrast, cave diving equipment differs substantially from open-water dive equipment.
Despite the substantial difference in appearance between cavern and cave diving equipment, both must meet several common objectives, including:

- Elimination of any dangling equipment that could become entangled in the guideline, disturb silt/sediment or damage fragile cave formations.
- Elimination of any unnecessary equipment items whose presence creates more problems than benefits.
- Making critical equipment items instantly accessible by feel.
- Making divers more streamlined by reducing drag and helping them achieve better body position.

**Configuration Overview**

Figure 18 is an illustration I created for a *Southern Diving* magazine article on cavern diving. The illustration and the explanation of each numbered item provide a good overview of a typical cavern diving equipment configuration. Following this are more detailed explanations of each area of equipment modification for cavern diving.
GETTING STARTED IN CAVERN DIVING

Figure 18: Anatomy of a cavern diver

1. Loose, floppy fin straps easily become entangled in guidelines. Secure them with duct tape or electrician's tape.
2. Tuck your mask strap inside your hood. This helps reduce the possibility of line entanglement and ensures a better fit.
3. Snorkels serve no function whatsoever in cavern diving and are a major potential source of entanglement. Make them go away.
4. Sevety-two degree water can be a lot colder than it sounds. A quarter-inch (6.5mm-7.0mm) farmer-john wetsuit with boots and hood helps ensure maximum comfort year round.
5. DIN fittings do a better job of protecting regulator-to-tank connections than yoke-style fittings do.
6. Alternate-air-source second stages must be secured with suitable attachment hardware and mounted as close to the BC as possible. They should not hang down more than a hand's width from your chest.
7. Long, dangling BC inflator hoses increase the risk of entanglement. Make certain yours are secured in some fashion to your BC shoulder strap. Consider having your local dive center replace needlessly long inflator hoses with shorter ones.
8. Your pressure gauge or console should have an easy-to-use snap or clip attached as close to its end as possible. Use this to fasten the gauge or console to a D-ring on or near one of your BC's shoulder straps. As with alternate-air-source second stages, it should not hang down more than a hand's width below your body.
9. Alleviate never allow a console, second stage or other equipment to dangle like this. Doing so not only increases the risk of entanglement in guidelines, it also increases the likelihood the equipment will contact the bottom, causing equipment damage, damage to the environment and—quite possibly—a deadly siltout.
10. Do not attach items to the D-rings located at the end of shoulder-adjustment straps. If you do, they will dangle too far below your body.
11. If possible, secure your backup light tightly to one of your BC shoulder straps, in a manner that does not allow it to dangle. This will make it readily accessible and easier to check for proper function.
12. Carry a razor-sharp line cutter where you can easily get to it, and where it will not cause entanglement in guidelines.
13. Your primary dive light should be of a size and shape that enables you to carry it in the same hand as the primary reel.
14. Carry one primary reel per buddy team. Use only reels designed specifically for cavern and cave diving.
15. Carry one safety reel per diver. Remove excess line from all reels to help minimize the possibility of reels jamming.
16. If your BC lacks suitable D-rings for carrying reels and other items, mount a D-ring on each side of the base of your tank, using a cam strap or large-diameter, stainless hose clamp. Items clipped to these rings will not tend to dangle below you.
17. Do not use the D-rings located at the bottom edge of most BCs to clip off reels or other items. If you do, the item will hang down several inches below you and greatly increase your risk of entanglement.
18. Use the least amount of lead possible. Weight-integrated BCs generally provide better balance and trim than divers can achieve using conventional weight belts.
19. If you need lead, configure the first five pounds as a drop weight. Leave this clipped to the guideline at the cavern entrance and retrieve it as you exit. (Diving to can greatly reduce the need for buoyancy adjustments inside the cavern.)
20. Large, leg-mounted dive knives generally do a poor job of cutting line and greatly increase the risk of entanglement. Do not use them for cavern diving.
21. Gloves are utterly unnecessary in north-central Florida's caverns and interfere with the ability to feel and control items such as guidelines and reels. Leave yours at home.
22. Bulky dive lights with pistol grips do not work well with reels and are, thus, unsuitable for cavern diving.
23. Dive light lanyards quickly become entangled in guidelines. Do not use them for cavern diving.
Mask and Fin Modifications

- The chief difference between a mask used for cavern diving and one intended for open water diving is the absence of a snorkel—Snorkels serve no purpose in cavern diving and pose a significant entanglement hazard.

- If at all possible, divers should tape down the loose end of fin straps to help prevent their becoming entangled in the guideline—Given the complex buckle assemblies found on many modern adjustable fins, this is not always possible. Your instructor will make specific recommendations regarding what you may be able to do to help prevent your fins straps and buckle assemblies from becoming entangled in the guideline.

Gas Delivery Equipment

Unlike cave divers, cavern divers can use the same type of regulator system as they do in open water. Such a system should include at least one first stage, primary and alternate-air-source second stages, a BC low-pressure inflation hose and a high-pressure hose with either a submersible pressure gauge and instrument console. Additional points to consider include:

- Because cavern divers should always be within the Emergency Swimming Ascent (ESA) zone, it is not necessary for them to have the additional regulator first stage and valve orifice that experts consider essential for both single- and double-tank cave diving.

- Because cavern divers should not be putting themselves in a position where they would have to share air while passing through a restriction, it is not absolutely necessary for them to have a seven-foot/two-meter second-stage hose on one of their first stages, as it is when cave diving.

More on Alternate Air Sources—As one can imagine, the potential need for two divers to share a single breathing gas supplies is an important consideration in cavern and cave diving. Passing a single second stage back and forth between two divers (“buddy breathing”) is simply not a realistic option when in overhead environments.

For cavern diving, each diver’s alternate air source must be readily accessible and not allowed to dangle in such a manner as to cause entanglement or damage—in other words, cavern divers must do what every open-water diver should do to keep his or her “octopus” under control. What follows is an excerpt from the book Ten Things Everyone can Learn from Cave Divers. It addresses this topic in greater detail.
Alternate-air-source ("octopus") second stages can literally be a lifesaver when another diver runs low on or out of air. An octopus is of little value, however, if you or your buddy can't find it quickly, or if it has been damaged through contact with the bottom (dangling octopuses are equally capable of causing damage to the bottom). This is why the major training agencies recommend that, instead of being allowed to dangle freely, alternate-air-source second stages be fastened securely to each diver, somewhere in the region between the diver’s mouth and the lower corners of his or her rib cage. Divers can accomplish this in one of two ways:

☐ If divers are using BC inflators that integrate an alternate-air-source second stage, doing so automatically meets the training agencies’ recommendations. This is because the second stage these divers will donate to a distressed buddy is already located in their mouths. These divers’ alternate-source-second stage, which is what they will breathe from after donating their primary second stage to the out-of-air/low-on-air diver, should be as easy to find as their BC inflator mechanism is, and also tend to fall within the triangular region recommended by the training organizations.

☐ Divers using conventional alternate-air-source (octopus) second stages should secure these to their BC harness somewhere within the triangular area the training agencies recommend, using a suitable attachment device. Such a device should hold the second stage securely enough to guard against accidental release, yet yield the second stage to a firm tug. The device should be easy to use, so that divers do not have to fight to connect their alternate-air-source second stage to it. It also helps if the attachment device comes with some form of snap or clip, to make it easy to attach to or remove from D-rings or attachment points on the BC harness.

The potential need to share breathing gas is a significant concern to cave divers. Should the need arise, cave divers might have to “share air” over distances of hundreds or thousands of feet, though poor visibility and restrictive passageways. As you would expect, the cave diving community has elevated sharing breathing gas to an art form.

Today, most cave divers are taught to donate their primary second stage (the one they normally breathe from). This will have a seven-foot low-pressure hose attached to it, to facilitate gas-sharing with another diver while passing single-file through a restricted passageway.

The extra-long low-pressure hose can be managed in a variety of ways. One increasingly popular method is to simply bring the hose down the right side of the tank(s), route it underneath the diver’s waist-strap-mounted light system battery pack, bring it up across the chest, back around
the back of the diver’s neck and, finally, to his or her mouth. In this manner, a single arm motion can pass a distressed diver not only a functioning second stage, but three to four feet of hose to go with it. A second arm motion, to unhook the hose from underneath the battery canister, makes all seven feet of hose available.

After donating the primary second stage, a cave diver so equipped then switches to his or her backup second stage, which is secured with a loop of surgical tubing or shock cord around the neck. This second stage will have a normal-length (or shorter) hose.

There are a number of reasons why an increasing number of cave divers prefer this method. Among them:

- The donor can locate and pass a second stage from his or her mouth faster than he or she can a second stage that is mounted elsewhere.
- The distressed diver gets a second stage that both divers know is functioning.
- As the donor is most likely not the one under the most stress, he or she can better afford to momentarily be without a second stage. The out-of-gas diver, on the other hand, may need to get a functioning second stage right now—not when the potential donor can manage to find one to pass. Besides, in so far as the donor has a backup second stage located only inches from his or her mouth, he or she will not be without breathing gas for long.

You sometimes hear divers state that, “the out-of-air diver will always go for the regulator in your mouth.” There is no statistical data proving this to be true all the time; however, we know it happens frequently. Divers whose normal gas sharing equipment configuration assumes passing the primary second stage (this includes cave divers “breathing the long hose” and open-water divers with integrated alternate-air-source inflators) are likely better prepared for another diver ripping a second stage from their mouths than divers configured otherwise.

However you choose to configure your equipment for air sharing, make certain that:

- Your alternate-air-source second stage is under control and not allowed to dangle freely.

- Whatever second stage a distressed diver ends up with, you are able to breathe from the one remaining.

Some open-water instructors teach students to mount a normal, right-handed second stage on their left-hand side. The logic in doing so is that students will be able to pass a distressed diver a second stage that is “right side
What these instructors forget is that, should the distressed diver simply take the second stage from the donor’s mouth, the donor will be left with a second stage that is now upside down, and may be unusable. (If you don’t believe this happens in real life, just ask a cave diver.)

**Guidelines and Reels**

Cavern divers should carry one primary reel per team and one safety reel per diver.

![Primary Reel and Safety Reel](image)

**Figure 19:** Common primary and safety reels, showing relative size.

**Primary Reel**—Deployed and retrieved by the team leader, the primary reel and its guideline help ensure that every team member always has a continuous guideline in place. In the event of a loss of visibility, each team member should be able to quickly make contact with this line and follow it to the cavern exit.

Although any reel carrying at least 100 feet/30m of line can function as a primary reel, most cavern divers prefer to use the same size primary reel as cave divers do. They should, however, place a mark on the line at between 100 feet/30m and no more than 130 feet/40m from its end. This will ensure the team remains within the maximum cavern diving penetration distance limit.

**Safety Reel**—In addition to the primary reel and guideline, which is shared by all team members, each team member—including the team leader—must carry a personal safety reel. Should any team member become separated from the primary guideline and not be able to see his/her teammates and/or the exit clearly, that team member can deploy his or her personal safety reel to conduct a search for the exit.

Even if the lost diver does not find the exit on the first attempt, having a safety reel helps ensure that he or she can return to the point at which the lost diver started the search, and try again in a different direction. By carry-
ing and using a safety reel, team members help guarantee they will not become “more lost” than they are when they first deploy their safety reels.

**Lights for Cavern Diving**

Cavern divers carry one primary light and one backup light; the sun counts as an additional light source, bringing the total number of lights to the required minimum of three.

Important primary dive light features include:

- **Size and shape facilitates use with reel**—Cavern divers must be able to hold their primary dive light and a reel in the same hand, while using both effectively. This rules out use of dive lights with pistol grips and many other larger dive lights.

- **Beam shape and intensity comparable with lights belonging to other team members to facilitate signaling**—If one team member has a light that is substantially more powerful than those of other team members, it will be difficult for these other team members to get the first diver’s attention.

- **Anticipated “burn” time equals or exceeds that of dive**—(This should be rather obvious…right?)

Important backup light features include:

- **Compact size for ease of storage and ready accessibility**—Ideally, a backup light should be compact enough to be attached to a BC shoulder strap without dangling.

- **Intense, highly focused beam for signalling other team members**—In so far as a backup light’s total output is likely to be less than that of other team members’ primary dive lights, its beam must be more tightly focused to help facilitate gaining the other team members’ attention.

- **Nonrechargeable batteries for dependability and long “burn” time**—Nonrechargeable batteries last longer and can withstand receiving less maintenance than rechargeable batteries. These are both benefits in that backup lights tend to receive less attention and care than primary lights, and may come on accidentally during dives.

Wrist lanyards are a significant entanglement hazard and have no place on any light used for cavern or cave diving.

**Attachment Hardware**

When selecting attachment hardware, consider:

- Resistance to accidental opening or breakage.
- Ease of operation by touch or feel.
Likelihood of accidentally trapping line.

The two types of clips most commonly used by cavern and cave divers are the sliding bolt (“dog leash” or “gate”) snap and pivoting latch (“boat” or “suicide”) snap.

**Sliding Bolt Snap**—The is the preferred snap for most situations. It is less prone to becoming stuck in the “open” position (a failure that can result in loss of equipment). It is also less prone to accidentally entrapping line. Its sole drawback is that it is not as easy to use as pivoting latch snaps. If a single snap will be all that attaches a particular item (such as reels) to you, this is the better choice. Many divers prefer to use only this type of snap.

**Pivoting Latch Snap**—This snap’s latch is more likely to fail by becoming stuck in the “open” position. It is also easier for this type of snap to function as its own line trap. Many divers, however, find it easier to use than sliding bolt snaps. The best application for snaps of this type is to use them to attach items such as instrument consoles, which divers must detach and reattach frequently (and which cannot become lost should the snap fail). Because of the potential for line entanglement, many cavern and cave divers prefer not to use pivoting latch snaps for any application. Those divers who do use such snaps should keep the open part turned inward, to minimize the possibility of line entrapment.

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**Figure 20:** Sliding bolt snaps are more reliable and less prone to guideline entanglement. Many consider this type of snap to be the best choice when a single piece of hardware is all that attaches an item to you. Pivoting latch snaps are among the easiest to use, and may be a good choice for items such as consoles, which you must detach and reattach frequently (and which will not be lost if a single snap fails).
Knives and Cutting Tools

Important considerations when selecting a knife or cutting tool for cavern diving include:

- Compact size.
- Razor sharp cutting edge.
- Ease of storage in a readily accessible place.

The vast majority of dive knives simply do not meet these qualifications. They are overly large, prone to entanglement and do not really do a good job of cutting line quickly or well. Consequently, many cavern and cave divers prefer to use an inexpensive parachute line cutter or similar cutting tool instead.

Figure 21: Simple, inexpensive cutting tools, such as this Z-Knife, are generally better suited for cavern diving than costly “dive knives” that don’t cut line particularly well.

Instrumentation

Minimum instrumentation for cavern diving includes:

- A submersible pressure gauge, preferably calibrated in 100 psi or 5-10 bar increments.
- A means of monitoring depth and time, such as a dive computer or depth gauge and timer.

Instruments such as thermometers and compasses have limited value in cavern diving. As is true of alternate air source second stages, instrument consoles should be attached securely to the diver’s BC or harness, and not allowed to dangle freely (see Figure 22).
Proper Weighting for Cavern Diving

Just as precise buoyancy control to help avoid silting and entanglement is an important component of cavern diving, proper weighting is an essential component of buoyancy control. It is difficult to practice precise, cave-diver-style buoyancy control unless one is wearing the least lead ballast possible.

Most recreational divers grossly overweight themselves. Given that most open-water diving accident victims make it to the surface at least once—only to sink permanently below the waves—you’d think recreational divers would be doing everything in their power to prevent this by not wearing unnecessary lead.

Wearing more lead than is necessary has additional drawbacks that apply equally to cavern and open-water divers. These drawbacks include:

- To compensate for the weight of their unnecessary lead, overweighted divers must add additional air to their BCs. This can substantially increase the overall drag they experience when moving through the water, resulting in increased gas consumption and exertion.

- Overweighted divers must not only compensate for buoyancy loss due to exposure suit compression, but also for buoyancy loss due to the compression of the unnecessary air their carry in their BC to offset the weight of the unneeded lead. This means they must use their BCs to make buoyancy adjustments far more frequently than properly weighted divers. Not only does this waste precious breathing gas, it helps increase the likelihood that overweighted divers will not have their buoyancy under control at all times.
Because overweighted divers tend carry unneeded weight below their bodies’ natural balance point—and compensate for this weight by adding air to a BC worn above this point—these divers tend to assume a head-up/fins-down position, as shown in Figure 22. This not only increases the resistance to movement (drag) they experience, the downward-directed thrust from their fins can have a devastating effect on visibility.

**Figure 22:** Overweighting does not facilitate achieving proper body position (trim) for cavern and cave diving.

Before one can even consider becoming a cavern diver, he or she must be able to properly weight himself or herself for diving in open water. This entails knowing when, where and how to conduct a weight check. (Hint: It is not when, where and how major training organizations suggest it is.)

The most effective time and place for doing a weight check for open-water diving—regardless of the type of exposure suit worn—is:

- At the end of the dive.
- At safety stop depth.
- With 500-1,000 psi/35-75 bar remaining.
Under these conditions, a properly weighted diver should be able to hover with no air in his or her BC.

Cavern divers have the further advantage of being able to use drop weights (see Figure 18) to compensate for the exposure suit compression usually experienced between the surface and cavern entrance. Upon entering the cavern, these weights should be clipped to the line for retrieval upon exiting. The benefits of using such weights are that doing so minimizes the need for buoyancy-control adjustments and helps divers achieve better body position.

Cavern divers have little, if any, need to wear weights in the normal quick-release configuration used by open-water divers; if weight is needed, it is best mounted where it will help divers achieve the best overall body position. The method of wearing weight that is most likely to result in poor body position is, ironically, a conventional weight belt.

4. Cavern Diving

Techniques/Procedures

In this section, we discuss:

☐ Propulsion Techniques.
☐ Guideline and Reel Use.
☐ Dive Planning.
☐ When to “Call” the Dive.

Propulsion Techniques

Cavern and cave divers use three primary propulsion techniques. These are:

☐ Modified flutter kick.
☐ Frog kick.
☐ Pulling (“Pull and Glide”).

Of these three propulsion techniques, pulling (“pull and glide”) has the greatest potential to cause environmental damage if not used correctly. Your instructor will demonstrate (and you will practice) all three techniques.

Guideline and Reel Use

Cavern divers generally make a primary tie-off in open water and a secondary tie-off just inside the cavern entrance. From this point until the divers tie off at the back of the cavern zone, the preferred method for controlling the guideline is to make placements instead of tie-offs.
Among the keys to successful guideline and reel use is to always maintain tension on the line. Also, when running a reel:

- Do not use tie-offs or placements occupied by other teams’ lines.
- Do not cross another team’s guideline.
- Do not lay your line in such a way as to interfere with another team’s ability to exit.

Your instructor will demonstrate and have you practice all aspects of guideline and reel use, first on dry land and, later, in the water. This is the best way to fully understand the basic points just discussed.

**Dive Planning**

The six elements a dive plan for cavern diving may include are:

- **Sequence**—Who will lead? Who will follow? Who (if anyone) will remain in the middle? Cavern and cave divers must be clear on this ahead of time, to avoid leaving team members behind. Also be aware that, when time comes to “call” the dive, the first diver in will be the last to exit; the last diver in will be the first to exit.

- **Air**—What turnaround points will help ensure each team member remains well within the Rule of Thirds? (More on this shortly.)

- **Depth**—What are the anticipated and maximum depth limits for the dive? (Not to exceed 70 feet/21m in any event.)

- **Duration**—What anticipated and maximum turnaround and total dive times will keep the team well within the no-decompression limits?

- **Distance**—Are there any landmarks, other than the edge of the light zone, that help demarcate the maximum allowable penetration limit of 130 feet/40m?

- **Direction**—Upon entering the cavern, which way will the team go? Right to left? Left to right? Straight back? Each team member must be clear on this, as well as clear on every other aspect of the dive plan.

A critical part of planning cavern and cave dives is determining the safest possible turnaround points, based on each team member’s starting gas volumes. Here are some of the terms we will use in explaining this process:

- **Penetration Gas**—That portion of a diver’s total breathing gas supply used to enter a cavern or cave. This should never exceed one third of the diver’s total starting gas volume (and, as we shall see, in situations in which team members have substantially different starting volumes, it
should never exceed the penetration gas volume of the team member identified as the *controlling diver*).

**Exit Gas**—This is the portion of a diver’s total breathing gas supply that he or she keeps in reserve to use while exiting the cave. It is determined by subtracting the diver’s penetration gas volume from his or her total starting gas volume. Exit gas volume must always exceed penetration gas volume by a factor of at least two to one. Thus, it should (hopefully) provide sufficient reserve to deal with the unforeseen.

**Turnaround Point**—The dividing point between penetration gas and exit gas.

**Controlling Diver**—The diver with the least actual starting gas volume. Note that this is not necessarily the same as having the lowest starting gas pressure, when using cylinders of different capacities.

When team members use identical cylinders, determining a gas turnaround point is relatively easy. This is due, in part, to the fact that when team members use cylinders of identical capacity, identical pressure gauge readings also represent identical volumes.

Here are the basic steps that team members using identical cylinders would follow to determine the safest possible turnaround points. Note that this procedure is the same, regardless of whether team members have identical, or different starting pressures.

**Identify the controlling diver(s)**—This is the team member (or members) with the lowest actual starting gas pressure. If all team members have the same starting pressure, they are all—in essence—the controlling divers.

**Determine the penetration gas volume**—If the controlling diver’s (or divers’) actual starting gas pressure is not a number easily divisible by three, round down to the next lowest number that is. One third of this number will represent the penetration gas volume for each team member.

**Determine the turnaround point for each team member**—Each team member should deduct the controlling diver’s penetration gas value from his or her actual starting pressure. (The controlling diver must remember to also deduct this number from his or her actual starting pressure and not the number he or she rounded down to.)
Here is an example that shows how this process works:

Divers A, B and C have identical cylinders. Diver A’s starting pressure is 3,400 psi; Diver B’s is 3,100; and Diver C has 2,900.

Diver C is the controlling diver. In so far as 2,900 is not easily divisible by three, Diver C rounds down to the next closest number that is, 2,700. The penetration gas volume is represented by one third of this number or 900 psi.

All team members therefore deduct 900 psi from their actual starting pressures. Thus, Diver A’s turnaround point becomes 2,500 psi; Diver B’s is 2,200; and Diver C’s is 2,000.

**When to “Call” the Dive**
The so-called “Golden Rule” of cavern and cave diving is that any diver may “call” any dive at any time, for any reason.

5. Communication

In this section, we will touch on the key points pertaining to:

- Command Signals.
- Light Signals.
- Hand Signals.
- Touch-Contact.

**Command Signals**

Command signals are ones that every member of the team must respond to in a certain way. These signals include:

- **Okay**—Just as in open water, this signal can be both a question and an answer. Once any team member uses this signal to pose the question, every other team member must confirm that he or she either is okay, or explain why he or she is not (any response other than “okay” generally means it is time to “call” the dive).

- **Hold**—Any team member can use this signal (a closed fist) to have other team members stop and hold in place. Once a team member gives this signal, the other team members must give the “hold” signal in response to indicate they understand clearly they are not to move. When the situation that first caused a team member to initiate the “hold” signal is resolved,
that team member signals “okay.” At this point, the other team members respond with “okay” signals, and the dive continues.

- **Surface (“call” the dive)**—This signal (an upward pointing thumb, as in open water), means that the dive is over, and all team members are to exit in sequence. As with all command signal, the other team members must give the “surface” signal in response to the team member who initiated it, to indicate they clearly understand the dive is over.

![Command signals](image)

**Figure 23: Command signals.**

The **Okay** signal may be a light or hand signal; the **Hold** and **Surface** signals may only be given and responded to using hand signals.

**Light Signals**

Light signals are among the easiest and most efficient to use. Commonly used light signals include:

- **Okay**—Simply move your light’s beam around that of fellow team members in a circular motion.
- **Attention**—A slow, wide sweeping light motion.
- **Emergency**—A short, rapid sweeping motion (this signal would most likely be used only in instances in which the signalling diver was suddenly without a breathing gas supply).
Hand Signals

Hand signals involving the use of crossed fingers pertain to the use of guidelines and reels. As shown in Figure 25, this signal can indicate messages such as “reel out,” “tie off,” “entanglement” and “cut the line.”

Other common hand signals include:

- **Silt**—Indicated by rubbing the thumb and fingers together. This signal is most often used to tell another team member that he or she is causing a silt out.

- **Question?**—Indicated by curving the index finger like a question mark and followed by other signals to explain the nature of the question. For example, **Question: Am I bubbling?**

- **Bubbles**—Indicated by bouncing the index finger off the tip of the thumb. This signal is most often used to ask a fellow team member whether your regulator or valve(s) are leaking, or to tell a fellow team member that his or her regulator or valve(s) is/are leaking.

- **Back-up Light On**—Backup lights often come on accidentally during a dive (your instructor can tell you how to avoid this). The backup light signal (fingers flashing like rays of light) can be used to tell a fellow team member that his or her backup light has come on.

- **Which Way?**—Indicated by pointing the thumb from side to side, this signal asks, “Which way do we go?”

- **Slow Down**—To tell fellow team members to slow down, move your forearm up and down, with your palm spread flat and pointing downward.

**Figure 24: Light signals.**
Touch-Contact

In situations involving loss of visibility, cavern and cave divers rely on touch-contact communication when exiting along the guideline. This is something you will practice extensively on land and in the water. The instructor will explain further.
6. Stress Management

Important things to keep in mind regarding the roll of stress in cavern and cave diving:

☐ Time pressure, peer pressure and self doubt are all potential causes of psychological stress.

☐ Cold, exertion and equipment problems are all potential causes of physiological stress.

☐ A certain level of stress is actually beneficial, as it helps keep divers alert and focused.

☐ An accumulation of psychological and/or physiological stress is often referred to as task loading.

☐ Panic is a sudden, unreasoning response to high levels of stress.

Among the best responses to exceptionally stressful situations is to simply do the following, in order:

☐ Stop.
☐ Breathe.
☐ Think.
☐ Act.

7. Emergency Procedures

Your instructor will discuss emergency procedures as part of the many field exercises taking place during the course. Among the points he or she will cover:

☐ In situations involving primary light failure, it is not okay to continue the dive after switching to your backup light.

☐ In situations involving loss of visibility, among the first things divers should do is to establish physical contact with the guideline, as well as with one another. They should maintain contact with the guideline and with each other until visibility either improves, or they successfully exit the cavern.

☐ In an emergency situation, such as loss of breathing gas, the distressed diver(s) should be positioned where other team members can watch him or her closely while exiting.