CASCADE CAVER

Cascade Grotto of the National Speleological Society

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Welcome

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"The cave you fear to enter holds the treasure you seek."

— Joseph Campbell

In This Issue

Letter From The Editor

By Mariana Tomas-Savage

The Cascade Caver hasn't been published since 2015, folks. In spite of my constant prodding and pestering, we didn't have any articles submitted in 2016. As you will soon see, 2017 proved to be much more prolific! I am really excited to present to you this one and only 2017 issue, and hope you enjoy the large variety of topics, from trip reports to lessons in caving techniques and a few others.

You will find contributions from long-time members as well as new members of the grotto. As the Cascade Grotto Secretary and newsletter Editor, I am very proud of what we got to show here and I really hope that the submissions keep on coming in this quantity and quality in the next year.

It is with mixed feelings that I have to announce leaving both positions (Cascade Grotto Secretary and Cascade Caver Editor) effective December 31, 2017. It's been two full years and I feel it is time for some new blood to stir things up a bit! Demands on my time have also grown exponentially, so it will be better not to take to many things on. I wish much luck and perseverance to the person(s) filling these roles, and many more issues of the Cascade Caver!

In addition to wrestling with MS Publisher software, my contribution to this issue are some photos from the annual Deadhorse trip dating to November 2016. Trip was lead by Brad Hutchinson, and in attendance were Janes Jones, James Moorshire, Madeline Schaller, Sid Creutz, Tyler Maxfield, Corey Bantam, Morgan Eastman, Mud Johnson, Aaron Brewer and myself.

Brad has been leading these annual trips for several years, but I unfortunately missed the one this year. November 4, 2017 trip which Brad led was attended by: Cory Bantam, James Mooreshire, Sid Creutz, Mckenzie Campbell, Kendall Davies, Morgan Jane Eastman Lorenz, and Dee Bowers . (Photo on page 4)

Please enjoy the one and only issue of the Cascade Caver in 2017, and let's toast to the happy, healthy, prosperous, and fun 2018, with lots of happy caving!

Cheers!

Mariana Tomas-Savage

Secretary, Cascade Grotto

Editor, Cascade Caver

December 31, 2017

Above: Brad and Aaron emerging from the low crawl.

Opposite page: Upper right: Tyler Maxfield in checking out the passage in the ceiling. Lower right: the crew is gathering around the pool.

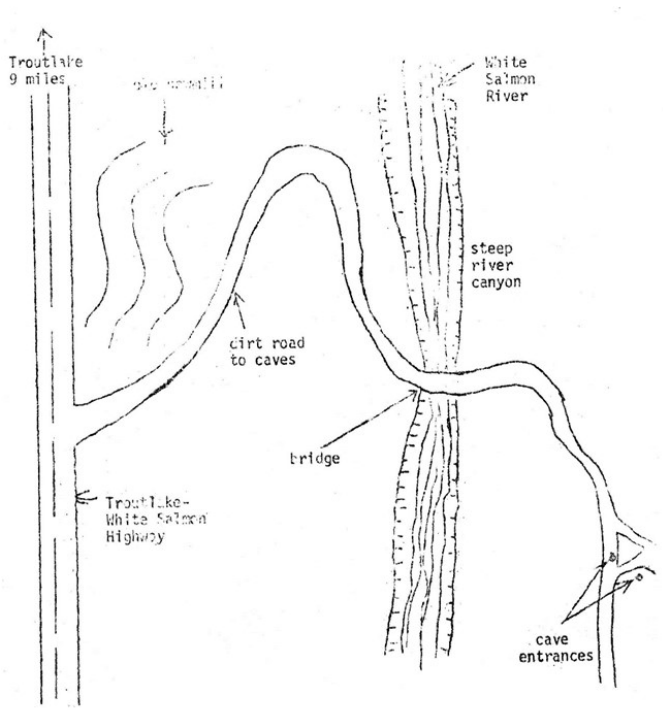
All photos by Mariana Tomas-Savage, Nov 16, 2016

Above: Deadhorse annual trip 2017. Photo by Brad Hutchinson.

Re-Discovery of White Salmon Cave

By Gary Petrie

On a small paper stub, the only description of White Salmon Cave was:" White Salmon Cave is 9 miles south of Trout Lake and 1 mile north of the Gilber Substation. Follow a dirt road east through an abandoned sawmill site and across the White Salmon River. Cave is in center of first fork in road. First entered by Jim Nieland, Jay Schwortz and Martin Deos in 1965, when they enlarged the entrance."

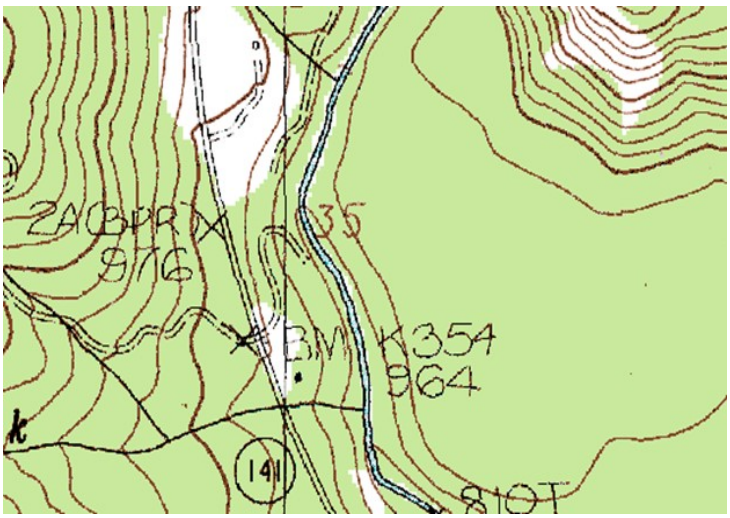


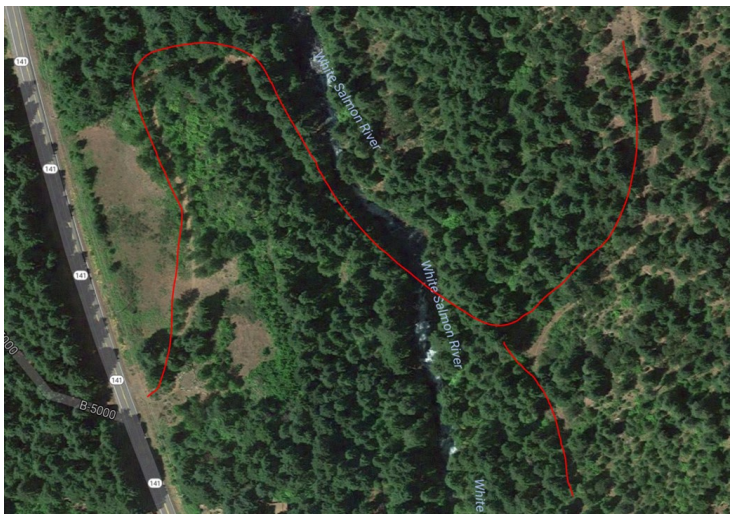
The first clue is the year 1965, a location map and story was found in the second volume, issue #3 of the Speleograph from 1965.

The problem is, following the White Salmon River from BZ Corners to Trout Lake, there is only one bridge and it does not match the drawing. The distance between the towns is about 10 miles and there is a PUD substation a mile north of BZ Corners. However, the only bridge is 2-3 miles further north of the substation.

The 1983 Guler Mountain USGS topographic map has this interesting dirt road in the approximate area where the river runs close to the Highway 141. Could the s-curved road ending at the river match the road in the Speleograph map? Where are the roads on the east side of the river? The Google aerial view of the same area reveals the long abandoned roads

In asking the local old timers, it turns out there was a "two log wide" bridge at the river crossing for the timber harvest on the east side of the river, now removed or destroyed.

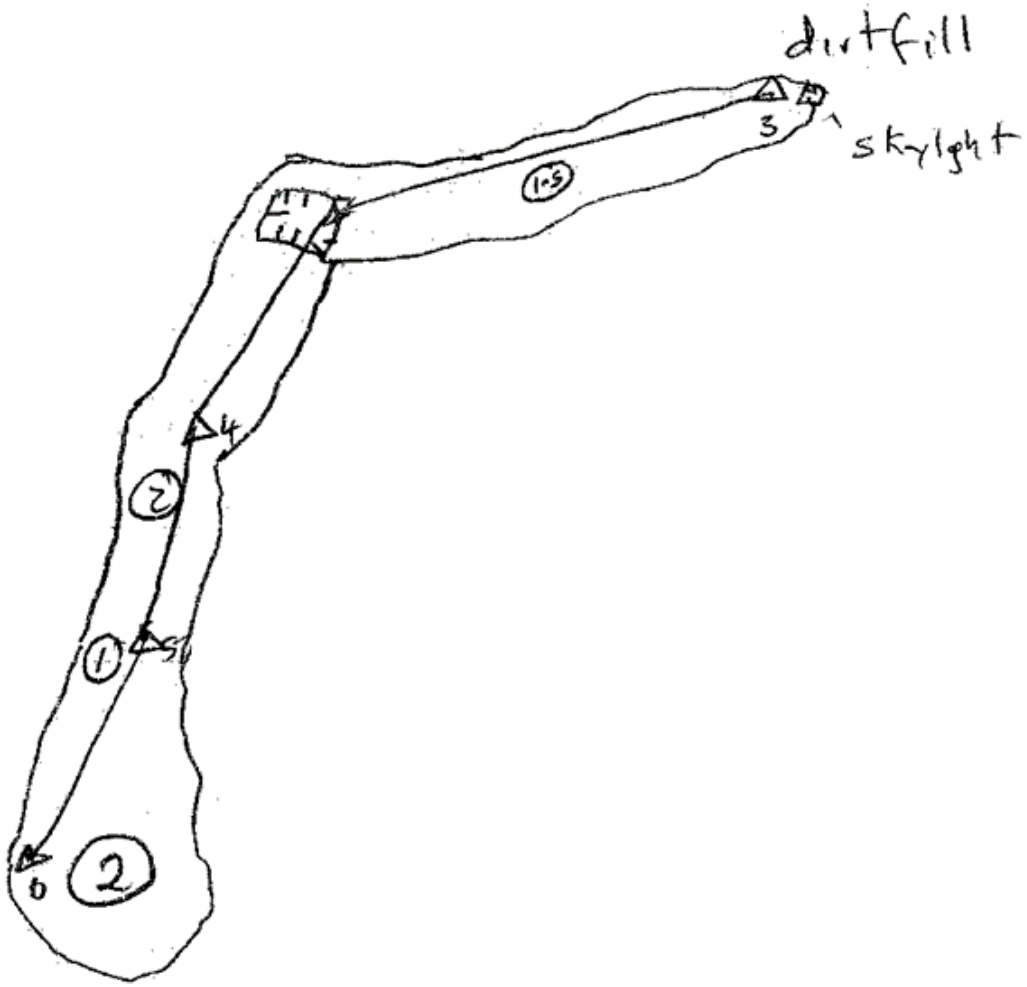




The remaining problem was the access. The lands on the east side of the river are owned by a combination of SDS Lumber Company and Washington Department of Natural Resources and foot traffic permitted. Unfortunately, the nearest road spur is about 2-3 miles distant, cross-country and without a trail.

The winter of 2014-15 had very lean snow pack and Bob Roe and I decided to make the trek to find White Salmon Cave that February. Starting on a road spur off the road to Glenwood from BZ Corners, we crossed over the ridge into the White Salmon valley. Following our GPS guidance, we found the old logging road on the east side of the river and headed north.

We found the entrance exactly as shown in the Speleograph, in the triangle defined by the three-way intersection of the old logging roads. It was approximately two feet square and the passage floor was only about three feet down, flat with original flow. The length of the cave was about 80 feet with entrance in the middle and a skylight at one end. Passage was crawling height and original flow. No other caves were found in the area



Vector Raises: A Minimal Equipment Rescue Technique

By Thomas Evans

Introduction:

Vector raises are a means of raising a load (often an injured person) with limited personnel and equipment. These systems exert high forces to raise the load, while only producing small vertical movements, yet only require one or two people to operate. As such, vector raises are an exceptionally good option for small party assisted rescues (SPAR) and should be considered when equipment and personnel are limited. With that said, these systems can be incredibly effective in accomplishing large call out rescues, so should also be considered when rigging complex systems would be too time consuming.

Rigging and Use:

In the simplest form, vector raises are two standing lines connected to a load with progress capture at the top of both lines (Figure 1). To operate the system, a person or people vectors one line to raise the load, and the slack created in the other line is captured as the load is raised (Figure 2). If rigged efficiently, one person can vector a line, and pull the tail of the other rope to capture progress (Figure 2). The maneuver is then repeated on the other line, thus affecting a raise with one person, or a small group of people (if more than one person vectors the line). This is most easily performed by vectoring the rope by leaning backward against the rope, and using your hands to haul on the slack rope, then turning around and leaning on the other rope with your body while taking in slack with your arms. This system works incredibly well when high forces are needed to bring up a load, like when an injured person is at the bottom of a pitch with a long roll over lip and other raising methods may not work as effectively (e.g., counterbalance systems like the diminishing loop counterbalance, Evans 2013).

Variations:

The beauty of vector raises is how many different variations are possible, making this technique easy to apply when little equipment is available. Any progress capture method will work, though some are better than others, and the systems can be built with a variety of software (rope, webbing, and cordage) in a few different configurations.

Figure 1: A complete vector raise system, two ropes with progress capture, a pulley and prusik for progress capture is shown. Though any progress capture will work.

Figure 2: Operation of a vector raise. Rig lines without slack (**A**), vector a line (**B**), pull slack out of the non-vectored line (**C,D**), vector other line (**E**), pull slack out of the non-vectored line (**F,G**). Repeat until the load is at the top.

Progress capture will be easier when the system will automatically capture progress when weight is lowered onto the slack line. Having a little extra equipment or a SPAR rigging kit (Evans 2015) is more than enough gear to rig these systems. A pulley and a prusik on both lines will work for progress capture (Figure 1A, Figure 2) as will any combined pulley and progress capture device (e.g., Roll N Lock, Micro Traxion, Kong Duck, etc.). Any locking hitch (Evans 2016) will work, though the most appropriate are probably the Remy Hitch (Figure 3A), Garda Hitch (Figure 3B), and any of the locking Münter Hitch options (not shown, see Evans 2016). All locking hitches require two carabiners (or a carabiner and screw link), so a total of four carabiners would be needed if both lines were rigged identically (Figure 3A, system built with Remy Hitches). If carabiners are in short supply, the system can be built with two Münter Hitches (Figure 3C), and when progress is captured tension is maintained on the Münter Hitch so progress is not lost when the line is loaded. Using two Münter Hitches will almost certainly require two people to operate.

While vector raises are most easily built with rope, they can be built with webbing and cordage as well. Webbing is weaker than rope, but can be safely used. The biggest problem with using webbing is that most webbing is carried in 20 to 30 foot sections, so multiple lengths will be tied together and knots will be encountered during the raise. Knots are easily moved through the system by vectoring one line, sliding the knot through the progress capture device, then lowering the load onto the progress capture device. Cordage is much weaker than webbing or rope, so is a last resort option. However, when it is available, it will work. Use the largest diameter cordage available!

When rope or webbing is in short supply, vector raises can be built with one piece of rope or webbing (or webbing tied together). Find the middle of the rope, tie a loop knot (butterfly, figure 8, overhand on a bight, or Bowline on a Bight) then rig the raise with the two rope tails (Figure 4). If additional resources arrive (personnel and equipment), it would be possible to convert either or both tails into haul systems. Practically, vector raises produce considerably more force than simple haul systems can, so converting the tails to haul systems would only speed up the raise/rescue if additional resources arrive. Alternatively the middle of the rope can be kept at the top of the pitch and both rope ends dropped to the load to rig a vector raise with a single rope.

To Belay Or Not To Belay:

Vector raises are a kind of two rope (redundant) system, with one line operating kind of like a main line (the line being vectored), as the other is functioning kind of like a belay (the slack line). Neither line is a true dedicated belay or main line though. During operation the system is not a two tension system. So vector raises are not purely one system or another, though there are two lines running to the load (redundant). This complexity may make some riggers uncomfortable. If you would prefer to have a separate belay, one can be added easily, though when this technique is most appropriate (minimal equipment and personnel), there is probably a shortage of equipment available to construct a belay. As such, practically this technique will not commonly incorporate a separate belay, but can and should during training.

Figure 4: Rigging a vector raise with one piece of software. Tie a mid-line loop knot (butterfly, figure 8 on a bight, etc.) in the middle of the software and rig the raise with the two tails.

Acknowledgements:

A cave rescue instructor taught me vector raises when I attended a National Cave Rescue Commission training years ago, so vector raises are not my idea! Reading numerous books, web forums, web pages, and interactions with other professionals inspired many variations presented here. These dedicated professionals and instructors deserve the credit for developing these techniques, and not myself; I serve only to document these methods. Sarah Truebe provided invaluable editorial advice and content suggestions, though all mistakes and omissions are solely those of the author.

Literature Cited:

Evans, Thomas, 2013, The Diminishing Loop Counterbalance, Proceedings of the International Technical Rescue Symposium, Albuquerque, New Mexico, November 7-10, 2013

(Also posted here: http://sarrr.weebly.com/small-party-assisted-rescue.html)

Evans, Thomas, 2015, Small Party Assisted Rescue (SPAR) Rigging Equipment, (http://sarrr.weebly.com/small-party-assisted-rescue.html)

Evans, Thomas, 2016, Auto-Locking Hitches,

(http://sarrr.weebly.com/technique-descriptions.html)

Tying a Prusik Quickly and Efficiently

By Thomas Evans

Introduction

The Prusik Hitch (PH) is a versatile rigging tool that can be used to ascend ropes, as a progress capture device, a belay (e.g., tandem triple wrap prusiks), a rope grab, and a variety of other functions. So knowing how to tie the PH efficiently is a useful skill for recreational and professional riggers. While there are a number of ways to tie the PH, one way is faster than the others, so using this method can reduce the time it takes to tie a PH. As such, this method is a useful addition to the riggers tool chest to speed up rigging.

Method Description

For a visual tutorial, see: (http://tiny.cc/quickprusik). Generally the method consists of using the dominant hand to rotate the prusik loop bend around the rope while the non-dominant hand simultaneously dresses the hitch. This two fold action speeds up tying the PH, produces a hitch that is correctly tied and dressed every time, and with the prusik loop bend out of the way in one of the limbs. This method takes a little practice, so try it a few times to get the hang of it.

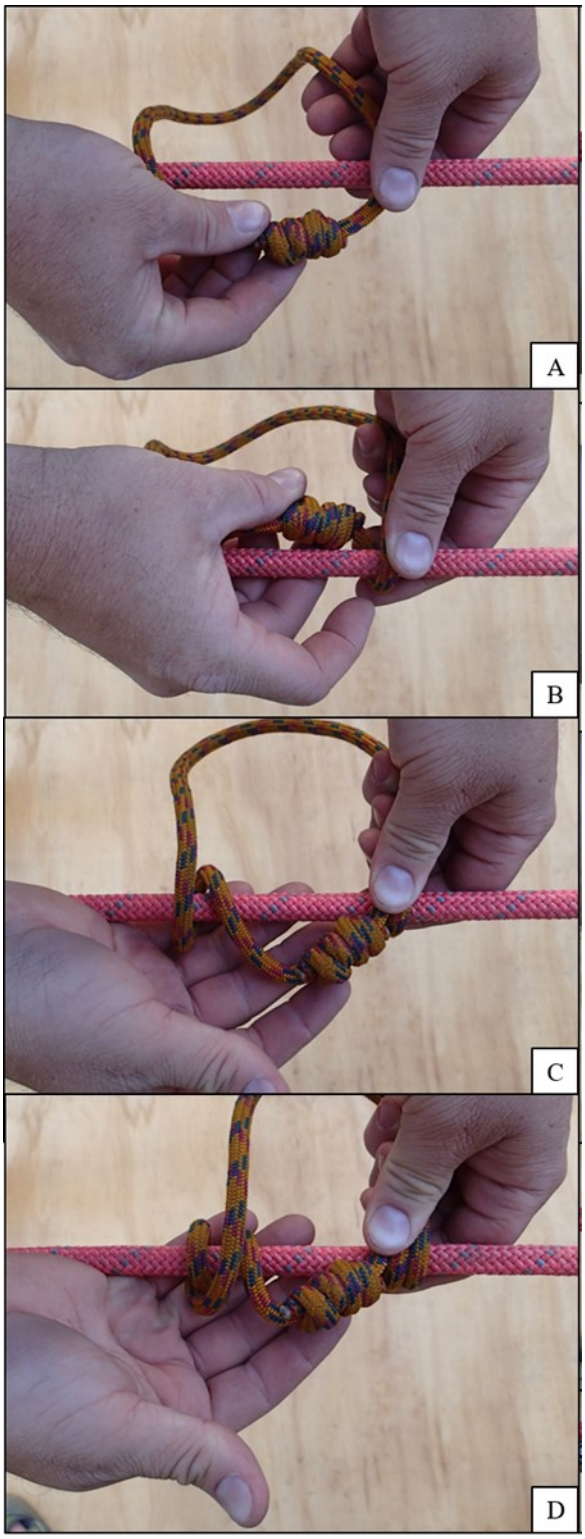
* Our apologies for the all the left-handers out there who are perpetually having to flip images and directions to get these things done.

1. Orient the prusik loop on top of or in front of the rope, with the dominant hand holding the prusik loop bend. For simplicity, tying will be depicted using a right hand dominant example. For left handed riggers, flip the images so the left hand is doing what the right hand is doing in the figures*. (Figure 1A)

2. Use the dominant hand fingertips to rotate the prusik loop bend around and behind the rope while keeping the bend close to the rope on the top side of the hitch. (Figure 1B)

3. Once a full turn around the rope has been completed, use the non-dominant hand to dress the top of the hitch by keeping the wraps tight and together. The bottom of the hitch will remain loose to facilitate additional wraps. (Figure 1C)

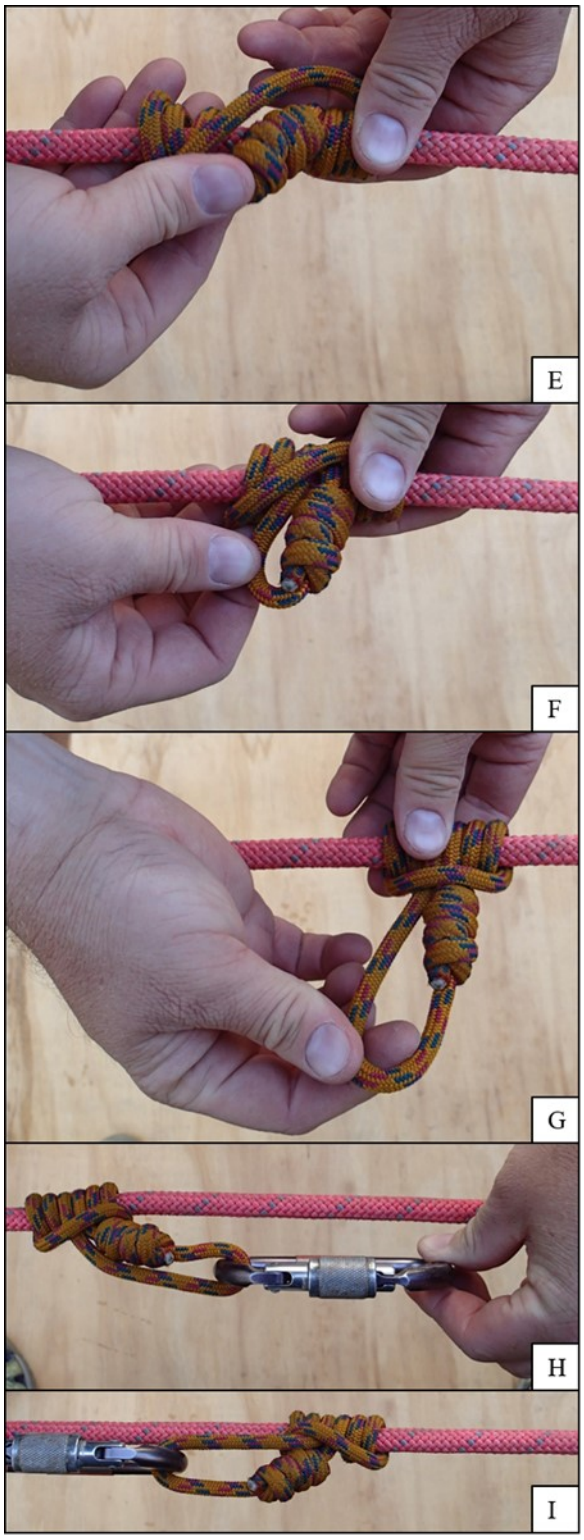
4. Keep wrapping the hitch with the dominant hand and dressing the top half of the hitch with the non-dominant hand until you have as many wraps as desired. The bottom half of the hitch is still loose. (Figure 1D)



5. Use the dominant hand to pull slack through the bottom of the hitch to tighten the PH (Figure 1E). As the loops tighten, they can be oriented and partially dressed with the outside fingers of both hands. (Figure 1F)

6. Once most of the slack has been moved through the hitch, dress the bottom of the hitch so all loops are parallel, then set the hitch by pulling on the hitch limbs with the dominant hand, and rotating slack through the hitch with the non-dominant hand. (Figure 1G)

Note: The strongest configuration of prusiks has the prusik loop bend in the PH strand closest to the load (Evans 2015). While the difference in strengths between the two configurations may not be important to you, if it is, start tying the prusik with the load toward your non-dominant side, which puts the bend closer to the load. This will yield the stronger configuration every time.



Acknowledgements

This technique was taught to me by an instructor for the National Cave Rescue Commission (NCRC), so this method is not of my making, but one I learned from someone else. Sarah Truebe provided valuable editorial advice, and suggestions for improving the information presentation.

Literature Cited

Evans, Thomas, 2015, Is There A Right Way To Tie A Prusik?

(http://sarrr.weebly.com/sar3-original-research/-is-there-a-right-way-to-tie-a-prusik)

SARRR, 2016, Tying a Prusik Quickly and Efficiently, (https://youtu.be/EcDwbjLzP70)

Small Party Assisted Rescue (SPAR) Rigging Equipment

By Thomas Evans

Introduction:

When recreating or working in the high angle environment, there is the potential for accident and injury. Injured individuals can wait for a professional rescue response, or they can start self rescue or small party assisted rescue, if appropriate, while awaiting additional resources. Because small party rescues can require a little more equipment, it is often prudent to carry a minimum of extra gear in case you or your group have to implement a rescue on the fly. Presented here are; a list of component parts that can be carried with which to perform a small party rescue with, descriptions of some of the many variations on the components, and photographic examples of different combinations with explanations for why different components were included. Examples are provided so you can learn what can be included in a personal rigging kit as well as how to alter what you bring depending on the conditions you will likely face.

Explanation of Parts/Components:

SPAR rigging equipment or kits typically contain some connectors (carabiners or screw links), some rope grabs (accessory cord loops -prusiks, Tiblock, Ropeman, etc.), webbing or sewn slings, a pulley or pulleys, and could contain a small rope or long piece of cord. Kits or extra gear now often include hybrid equipment like Micro Traxions, Kong Ducks, or Roll N Locks that are both a pulley and progress capture device. These components can be used to build raising or lowering systems, a personal ascending system, replace broken or lost rigging equipment, or build new anchors. Consequently, having a little extra gear in case of emergency can be invaluable to someone who knows how to use the equipment effectively and efficiently to perform a rescue or improvise on the fly.

Common SPAR Rigging Kit Variations:

A common SPAR rigging kit or extra gear includes 2 carabiners, 2 rope grabs (prusik loops), 2 pulleys, sometimes 1 or 2 lengths of webbing, and (optional but handy) a short piece of 8/9mm rope or cordage. If each person in a group carries some extra gear the kit can be divided as rigging components are spread between packs (e.g., a person carries 1 carabiner, 1 prusik, 1 pulley, and maybe webbing). Many variations exist on the specific components you bring. The table below briefly covers the pros and cons of including different rigging components in your kit. Customize your kit as appropriate given the location and conditions you will experience.

Component	Common Variations	Pros	Cons
Connectors	Carabiners	Quick connections, some lock	Larger and heavier than screw links
	HMS Carabiners	Easy to tie and operate Münter Hitches (good for short belays)	Usually larger than other carabiners
	Screw Links	Light, small, and strong	Take longer to rig, and being small they are often cumbersome to use
Rope Grabs	Short Prusik	Great for fast connections to ropes	If too short, can be hard to use as progress capture in a haul system
	Long Prusik	Fantastic for progress capture in conjunction with a pulley	Bigger and bulkier
	Extra Long Prusik	Great for foot loops in climbing systems, and anchors	Biggest and bulkiest
	Mechanical Rope Grabs	Captures progress more efficiently, often found in combination pulley/progress capture devices	Often heavier, can strip rope/cord sheaths, less versatile than accessory cord (e.g., cannot be used for as many functions)
Pulleys	Personal Rescue Pulley	Lightweight, small, and strong	Do not mind prusiks well in haul systems
	PMP Personal Rescue Pulley	Can mind prusiks in haul systems	Slightly heavier than personal rescue pulleys
Webbing	1 Inch Tubular Webbing	Versatile, can be tied into any desired configuration	Not as strong as Dyneema sewn slings, though strong enough
	Sewn Slings	Strong and fast to rig, Dyneema slings are lighter and less bulky	Limited because they are sewn in loops of predefined lengths
Rope/Cordage (Optional)	Small Diameter Rope (7-9mm rope)	Fantastic for building haul systems and belays over short distances	Big, bulky, and can be heavy
	Large Diameter Cord (7-9 mm cord)	Smaller than rope, and can build haul systems	Weaker than rope, and often stretches more than rope

A. A common SPAR rigging kit
B. HMS carabiner added for ease of making short belays for protecting small climbs (Münter hitches)
C. Cord added to make multipoint anchors or short haul systems
D. Rope and HMS carabiner added for belaying short dangerous (exposed) climbs
E. A heavy/large rescue kit for beginner trips or large groups where having more gear may be advantageous
F. Webbing removed to reduce bulk, or few anchors anticipated
G. Smaller and lighter kit for tighter caves, or more extreme approaches, can be split between members of the group
H. The common rigging kit divided up between two members of the same party
I. Light weight rigging kit for alpine caves, or for longer trips, can also be separated into two packs. Smaller kits are better for more advanced riggers/users.
J. A small lightweight kit big enough to build the Diminishing Loop Counterbalance. Smaller kits are appropriate for advanced users.

Examples-Pictures of different SPAR rigging equipment optimized for different environmental conditions. These different kits are presented as examples, not as ideal kits. Ultimately what you carry is a matter of personal opinion based on experience, rigging skill, and what you can afford.

An Introductory Guide to Carabiners:

Anatomy, Form, Function, Use, And Maintenance

By Thomas Evans

What is this guide and why is it necessary?

People that recreate, volunteer, or work in a high angle environment frequently have little training in the nuances of carabiner form and function because instructors perceive this information as obvious or of little value. This has led to a population of recreational and professional carabiner users that know enough about carabiners to be safe on rope, but often do not get the most out of the equipment they use and own. This document puts the fundamentals of carabiners in one place as a reference guide for new users and a reminder for frequent users. The intent is to facilitate more efficient and safe rigging through greater awareness of nuanced carabiner use.

This guide starts by describing carabiner anatomy, markings, and carabiner shapes and their uses. Carabiner materials, gate variations and their functions, are described, followed by a discussion of equipment compatibility, how to choose carabiners, basic use,

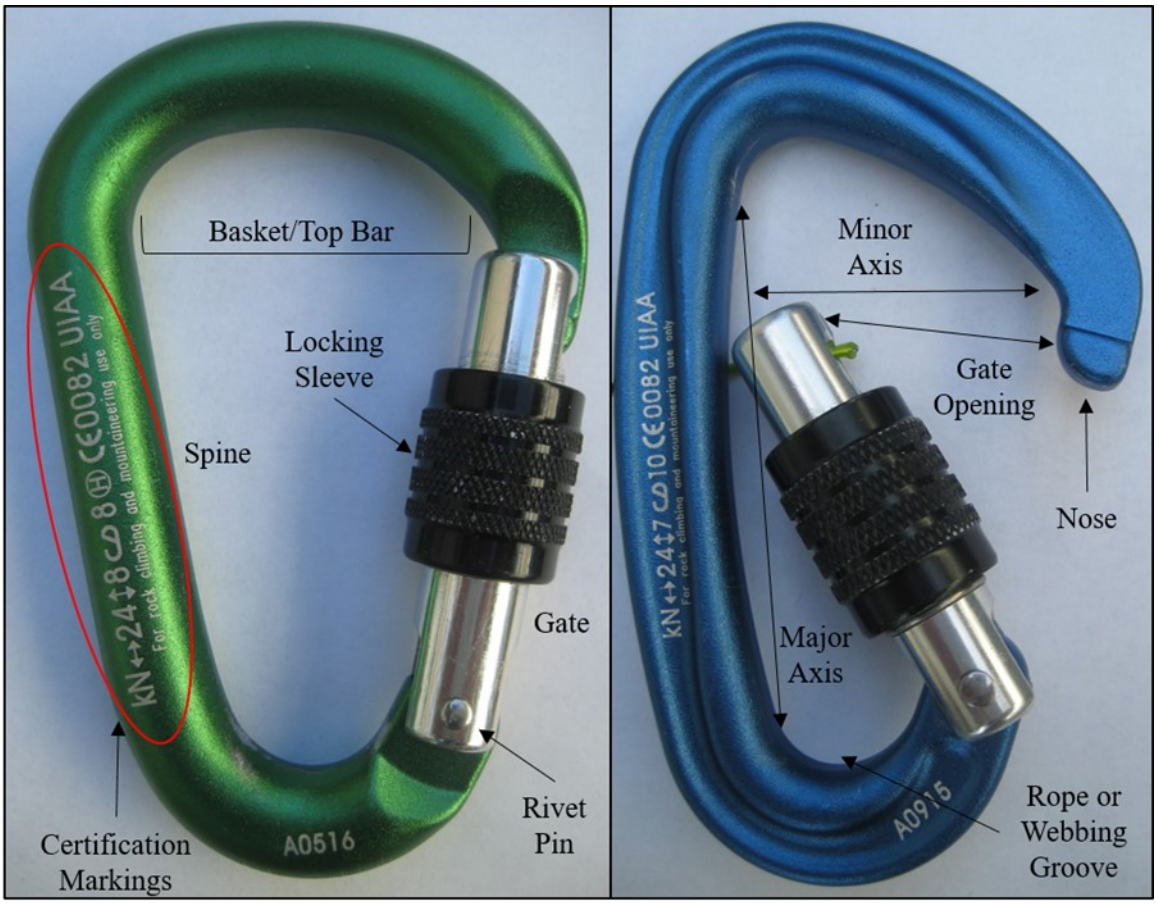


Figure 1: Carabiner anatomy. Carabiner markings circled in red.

Carabiner Anatomy

To understand the rest of this discussion you need to know the parts of the carabiner (Figure 1). While the shapes, sizes, and varieties of carabiners are many, they all have the same or similar parts, so learn the parts of a carabiner so you can communicate with other users cogently.

Carabiner Markings and Certifications

Figure 2: Carabiner spine markings; carabiner strength in kilonewtons when loaded along the long axis (top figure circled on the left), gate loaded (circled in bottom figure), and loaded along the long axis with the gate open (top figure circled on the right). Certifications are underlined with brackets in both images. These carabiners are certified to both CE and UIAA standards.

Important information is stamped on carabiner spines manufactured for life safety applications (Figure 2). This includes carabiner strength when loaded along the long axis with the gate closed, when loaded across the short axis (gate loaded), and when loaded along the long axis and the gate is open (Figure 2, markings in the circles). The numbers are expressed in kilonewtons (kN), the metric unit of force. A kN is equal to 224.80894 pounds, so to convert between kN and lbs, multiply or divide by 224.8 or ~225. These markings indicate the minimum force the carabiner manufacturers will guarantee their product can hold without failure in the indicated configurations. Next to the strength markings are any national or international certifications if the carabiner has been certified to any (Figure 2, underlined markings). These markings indicate that the carabiner meets the minimum requirements of a given standard agency. Common markings include those from ANSI (American National Standards Institute), NFPA (National Fire Protection Association), UIAA (International Climbing and Mountaineering Federation), and CE (Conformite Europeenne). Generally, if a carabiner has a marking from any of these groups, the carabiner is strong enough for life safety applications. However, ANSI typically regulates equipment used in industrial contexts, while NFPA is a manufacturers' standard for equipment designed for the Fire Service. The UIAA sets standards for recreational climbing and mountaineering equipment, so UIAA marked products are most applicable for sport applications. If your carabiner use falls under the regulations of any of these organizations, use carabiners certified to their standards. Ultimately, a carabiner that meets any of these certifications is a quality product; just some products are designed and manufactured for different purposes, so purchase carabiners with the appropriate certifications for your intended use (e.g., UIAA for sport applications, etc.). None of these strength ratings and certifications, however, can inform you about carabiner strength when a carabiner has use wear or has experienced abnormal use or abuse. So consider these strengths as minima until carabiners have been abraded during use.

Carabiner Shapes

Carabiner shape alters performance. Users should ideally use the right shaped carabiner for particular functions. Figure 3 shows the four most common carabiner shapes, and Table 1 explains their strengths and weaknesses.

As a general rule, the size of the basket or top bar controls how many items can be clipped in to the carabiner. The wider the top bar the more items can be clipped in the carabiner. Similarly, the shape of the top bar controls how well items stay in place. Rounded top bars like on HMS or Oval carabiners keep materials more or less cantered on the carabiner basket, and not along the carabiner spine which causes leverage of the top bar relative to the spine. D and Offset D shaped carabiners have top bars that facilitate items slipping down the basket next to the spine. This variation in carabiner performance based on shape means that some carabiners are compatible with some items and not others. For a more thorough discussion of this topic, see the section on the "Concept of Compatibility".

There are many other carabiner shapes, some specifically designed for one function or another, or carabiners that have a twist, so are three dimensional. Each of these carabiners is a specialty model designed for specific functions. These unique carabiner shapes and designs are not explored here because there is not enough space to cover the many variations (but see Figure 10).

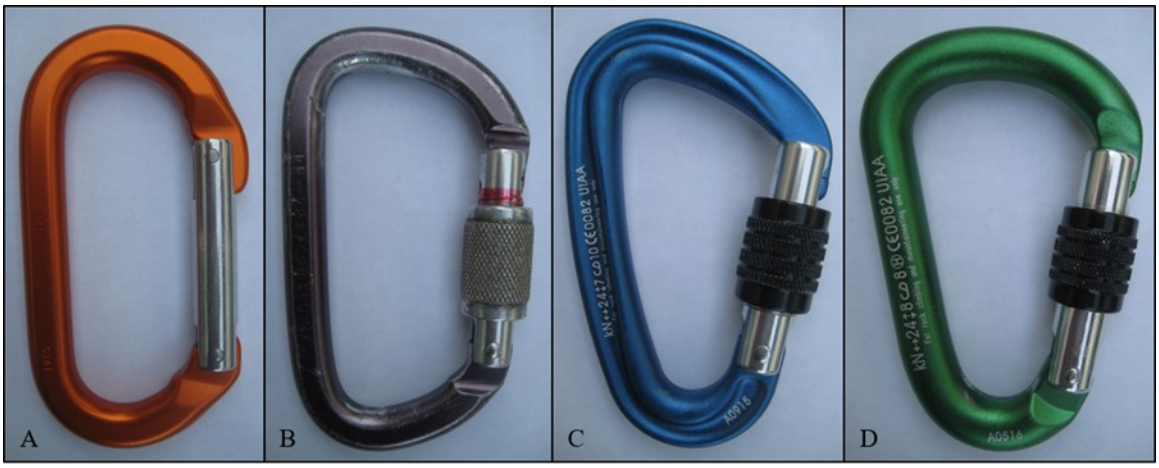


Figure 3: The four most common carabiner shapes; **A**) Oval, **B**) D, **C**) Offset D, and **D**) Halbmastwurfsicherung or HMS for short.

Table 1: Common names for the four most common carabiner shapes, including their strengths, weaknesses, and some example uses of each.

Carabiner Shape	Synonyms	Strengths	Weaknesses	Common Applications
Oval		Nearly the same strength even in different rigging configurations; more consistent strength when tri-loaded Can hold more gear than a D shaped carabiner Flips/rotates easily when unweighted, minimal movement when weighted Prevents load from shifting during loading (load always stays at bottom of the carabiner)	Weakest of the carabiner shapes Smallest gate opening Heavier than other shapes Harder to clip than other carabiner varieties, because of the smaller gate opening size	Mountaineering Racking protection Aid climbing
D		Strongest of the carabiner shapes when loaded along the spine Lighter than ovals and HMS carabiners of the same size Larger gate opening than oval carabiners	Strength is dependent on rigging configuration Heavier than offset D carabiners Smaller gate opening than Offset D and HMS carabiners	Fixed rope anchors (e.g., caving, top rope anchors) Rescue rigging
Offset D	Asymmetric D	Larger gate opening than oval or D shaped carabiners Can hold more equipment than a D shaped carabiner Lightest carabiner for its strength and size Narrow end holds software in place well	Smaller gate opening than HMS carabiners Smaller space inside the carabiner than an HMS Strength is dependent on rigging configuration	Quickdraws Climbing anchors
Halbmastwurfsicherung (HMS for short)	Münter Pear Belay	Can clip the most equipment of all the carabiner shapes Largest gate opening of the carabiner shapes Can clip larger items than other carabiner shapes	Heavier due to their larger size Weaker than D's and Offset D's	Belaying Rappelling Climbing anchors

Bar Stock Shapes

In addition to carabiner shape, the shape of the bar stock carabiners are made from also affects performance (Table 2). Generally, the larger diameter the bar stock the more wear the carabiner can absorb before structural compromise (Figure 3d). Larger diameter also improves the pulling of software (rope, cord, and webbing) over the carabiner, which can be incredibly useful during pulldown rappels or use of improvised haul systems. I-beam style bar stock (Figure 3c) yields lighter carabiners than round or flat stock, but these carabiners wear faster than those constructed from cylindrical bar stock (Figure 3d). So, for best results, use I-beam style bar stock carabiners when you wish to minimize weight and the carabiners are not expected to experience considerable abrasion (e.g., climbing quickdraws), and use round bar stock carabiners when they will experience considerable abrasion (e.g., when rappelling or belaying with a Münter Hitch). Some carabiners are built with I-Beam style spines and cylindrical top bars, which provide a compromise between the two types (Figures 5h,k, 10c). Mixed bar stock carabiners are considerably more expensive, are a bit lighter, and tolerate abrasion more.

Table 2: General characteristics of common bar stock variations

Bar Stock	Pros	Cons
Cylindrical	Increased wear lifetime Cheaper	Heavier
I-Beam	Lighter	Decreased wear lifetime More expensive

Materials

The vast majority of carabiners are constructed from either aluminium or steel, and can come with a few different coatings. All carabiner materials and coating variations have their place in sport, rescue, and professional rigging, so use the materials that are most appropriate for your usage. A comparison of the pros and cons of both materials and their coatings are in Table 3.

Figure 4: Carabiner gate variations. **A**) Solid straight locking (screw) gate carabiner, **B**) Solid straight nonlocking gate carabiner, **C**) Solid bent nonlocking gate carabiner, and **D**) Wire straight nonlocking gate

Gates

Carabiner gates are designed with a variety of features to create products with a suite of desired characteristics, making gate features the greatest variability in carabiner design. It is impossible to cover all the gate variations in one short review, so the most common gate variations are depicted in Figure 4 and reviewed in Table 4. The table is organized with dichotomous gate variations, like locking versus non locking. In many cases multiple gate variations are built together, like a straight solid locking gate, or a straight wire non-locking gate. Ideally acquire carabiners with the desired characteristics to achieve optimal performance. If needed, use Table 4 to identify the gate variations with the properties you need.

Locking carabiners can come with a range of locking mechanisms that can be divided into two categories, manual-locking (screw gates most frequently) and auto-locking. The pros and cons of each type are presented in (Table 5).

Table 3: Pros and cons of carabiner construction materials, and example uses.

Material	Pros	Cons	Uses
Aluminum	Much lighter than steel Strong enough for nearly all uses	Weaker than steel Abrades more readily than steel More prone to chemical corrosion than steel	Used when reducing weight is important Climbing, backcountry rescue
Annodized Aluminum	Shields carabiners from corrosion Is more abrasion resistant Increases lifespan of hardware	More expensive than aluminum alone Coating wears through rapidly when abraded	Used when reduced weight and corrosion resistance is important Sea side climbing
Stainless Steel	Stronger than aluminum Abrasion resistant	Heavier than aluminum Stronger than is needed	Used when strength and robustness is needed Abrasive or corrosive environments Industrial rescue, cave rescue
Steel Alloy	Stronger than aluminum Abrasion resistant	Heavier than aluminum Stronger than is needed	Used when strength and robustness is needed Abrasive environments, but corrosion unlikely
Steel Alloy, Zink Plated	Stronger than aluminum Abrasion resistant	Heavier than aluminum Stronger than is needed	Used when strength and robustness is needed Abrasive environments, but corrosion rare
Steel Alloy, Black Oxide	Stronger than aluminum Abrasion resistant Partially corrosion resistant	Heavier than aluminum Stronger than is needed	Used when strength and robustness is needed Abrasive environments, but corrosion rare

Auto-locking carabiners also come in many forms and are classified by how many motions it takes to unlock them. Self-locking varieties require only one motion to open, while double- and triple-locking require two and three motions to unlock. For example, retracting a sleave and twisting for a double-locking carabiner, or twisting, retracting a sleave, and twisting again for triple-locking carabiners. There are even quad-locking carabiners that require four motions prior to gate opening. Generally, the more motions it takes to open a carabiner, the harder it is to unlock and open. In some cases the need to perform so many gate manipulations reduces carabiner functionality, so some gates are even equipped with features to lock a gate open (Figure 5c,e), somewhat negating some of the safety features of locking carabiners. Figure 5 depicts many locking carabiner variations as examples of locking mechanism types.

Noses:

Nose shape governs how easy it is to clip and unclip a carabiner, so can be the deciding factor in how easy it is to use a carabiner. There are two components of shape that greatly affect performance, the nose angle (the shape of the top bar near the nose), and the connection between the gate and the carabiner frame.

Smooth nose angles make clipping and unclipping objects easier while sharp curves lead to more frequent snagging during clipping and unclipping (Figure 6). If the ease of clipping and unclipping objects is important to you, then a carabiner with a smoother curvature between the nose and the top bar is more appropriate. For example, cow's tail or quickdraw carabiners are often clipped and unclipped frequently, making smooth nose angles more important for these carabiners.

Gate closure designs have changed markedly as carabiner engineering has improved. The earliest

carabiners had claw style connections (Figure 7a,f), with some part of the frame interlocking with the gate. An improvement on the claw design was the hook and pin design, with a pin in the gate fitting in a hook on the nose (Figure 7b,g). As hook and pin carabiners are loaded, the frame extends, locking the pin into the hook, making carabiner opening more difficult. Both claw and hook and pin noses have a tendency to catch on items as they are being clipped. So while the hook and pin is a better design than the claw, they can catch on everything from webbing and rope to bolt hangers. Generally, the deeper and larger

Table 4: Common carabiner gate variations.

Carabiner Gate Variations	Pros	Cons	Example Uses
Non-locking	Lighter	Can open unintentionally (e.g., gate flutter)	Quickdraws
	Easier to operate		Racking gear
Locking	Holds gate closed securely	Heavier	Best for single point failure locations
	Improved security	Can lead to complacency	Industrial and rescue rigging
		Harder to unlock and open	Connecting rappel devices to harnesses
		Sand and mud can foul up locking mechanisms	Connecting to anchors
Wire	Lighter	Less durable than solid gates	Climbing
	Reduced potential for gate flutter*	Often more expensive than solid gates	
	Fewer moving parts to break, get stuck, or freeze	Sometimes harder to operate than solid gates	
	Clears snow, ice, mud, and sand better	More expensive	
	Larger gate opening compared to solid gates		
	Wire gate carabiners are just as strong as solid gate carabiners		
Solid	More robust	Heavier	Locking carabiners
	Sometimes slightly stronger than wire gates	More prone to gate flutter than wire gates*	
	Easier to operate	Can lead to rigging complacency	
	Often cheaper than wire gates	Sticks/freezes shut more frequently	
		Reduced performance in snow, ice, mud, and sand	
		Smaller gate opening	
Bent	Easier to clip ropes	Harder to manufacture	Bottom carabiner on a quick draw
	Wider gate opening	More expensive	
	Some consider them more ergonomic		
Straight	Easier to manufacture	Harder to clip onto a rope	Most locking carabiners
	Cheaper	Smaller gate opening	
		Some consider them less ergonomic	
Inline Hinge	Easier to manufacture and cheaper	Smaller gate opening	Vast majority of carabiners
	Some consider them more ergonomic	Some consider them less ergonomic	
Offset Hinge	Larger gate opening	Harder to manufacture and more expensive	Cordelette climbing anchors (accommodates large focal knots)
	Some consider them more ergonomic	Some consider them less ergonomic	

*Reference [5]

Table 5: Locking carabiner gate variations.

Mechanism Type	Pros	Cons	Example Uses
Manual mechanism (commonly screw gates)	Locks when you wanted it locked, unlocked otherwise Lighter than autolocking mechanisms	Has a manual mechanism, so can be unlocked May become unlocked during use	Rappel or belay device carabiner Back Country Rescue
Autolocking (numerous variations)	When the gate closes, the carabiner is locked Greater rigging security Locks faster and more securely Impossible to forget to lock them	Can lead to complacency Often annoying to open Can often need two hands to unlock Can be difficult to open with gloves on Can lock when you want it unlocked and open More parts to fail in harsh environments (e.g., sand, mud, silt, etc.) Heavier gates	Rope access Industrial rescue

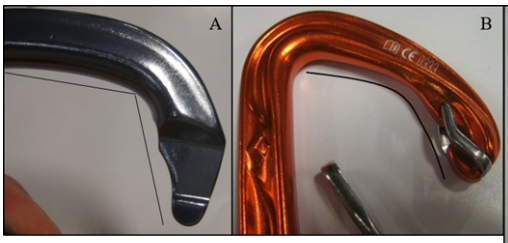


Figure 6 (Above): Sharp nose angles (**A**) make clipping and unclipping more difficult, while smoother nose angles (**B**) reduce catching on objects while making connections.

Figure 7 (Right): Nose closure options. Claw (**A,F**), Hook and Pin (**B,G**), Key Lock (**C,H**), Pin and Notch (**D,I**), and Shrouded (**E,J**).

the hook, the greater the chance of snagging. Ensure hook and pin carabiners are completely closed when loaded, because nose loaded carabiners caught on anything are considerably weaker than closed gate carabiners [2,7,15]. More recently the key lock design for solid gates (Figure 7c,h) and pin and notch design for wire gates (Figure 7d,i), has greatly reduced the tendency of carabiners snagging. Key locks have a rounded nose that does not snag as they are clipped to objects, yet the nose locks into a matching hole in the gate, so securely connects the nose and gate when the carabiner is loaded in extension. The same holds true for pin and notch designs. With the demonstrated success of key lock and pin and notch varieties, manufacturers designed wire gates so they would have similar snag free performance. These shrouded or “clean nose” wire gate carabiners have mettle wrapping around the connection of the wire gate with the frame (Figure 7e,j) which reduces gate snagging, gate opening when dragged across rock surfaces, and reduces accidental opening during use. Ultimately, to reduce hanging up on objects while clipping a carabiner, a key lock, pin and notch, or shrouded carabiner is preferred.

Size:

Carabiner size directly effects performance both in gate opening size, and overall size. Larger gate openings improve the ease of clipping items, and facilitate clipping more items. Overall size has pros and cons on the two extremes. Generally, larger carabi-

Figure 5: Some carabiner locking mechanism variations. **A**) Manual locking (screw gate), and **B-K**) Auto-locking gate variations. Self-locking (**B,G**) and double-locking (**C,D-F,H,I**) carabiners come in many forms, with many locking mechanisms; spring loaded locking sleeves (**B-E**), ball lock (**F**), magnetic locking mechanism (**G**), and opposite and opposed gates (**H-K**).

ners are easier to operate because they fit in the hands better, so are easier to operate with gloves on. Larger carabiners can also clip and hold more materials. Smaller carabiners are lighter, take up less space, but are harder to open and clip than larger carabiners, and can clip and hold fewer materials. Over time the number of carabiner sizes has slowly increased as materials and manufacturing methods have improved. Presently carabiners come in a continuum of sizes, but five are common (Figure 8); micro/mini, small, medium, large, and industrial. The carabiners we are used to seeing in most sport rigging are small and medium, and those often used in the fire service and rescue are commonly large (though not always!). Industrial sizes are for exceptionally large carabiners and snap hooks used for specific functions, and their use is outside the scope of this document. Small and micro/mini carabiners have become more common in the past few years as manufacturers have improved carabiner design and construction. Smaller sized carabiners have become a favorite of climbers who need full strength carabiners, but who benefit from reduced equipment mass.

Colors:

Carabiners can be purchased in a wide array of colors (Figure 9a). For most users, having different colored carabiners is not necessary or useful. However, some users find having differently colored carabiners useful in organizing or racking their gear. For example, racking nuts on one color of carabiner for ease of location and use. Or racking protection of different sizes on different carabiner colors. Some users also find one color or another more aesthetically pleasing so purchase equipment of that color. Others simply prefer to have differently colored equipment from their friends so their friends do not walk off with their gear! Ultimately, differently colored carabiners simply encourages some users to buy more hardware than needed, so is sometimes just a marketing gimmick. Consistent with advice from other sections of this work, purchase carabiners that have the characteristics you need or desire. So if different colors are useful or you just want a different color, go for it.

Locking carabiners will frequently use color(s) to indicate when they are locked or unlocked. For example, some screw gate carabiners have different colors on the gates that are covered when locked or uncovered when locked that act as a visual cue to users that the carabiners are in the configuration desired (Figure 9b-e).

Figure 9: Carabiners can come in a range of colors, which can be useful in organizing equipment (**A**). Some locking carabiners use colors as a way to indicate they are locked or unlocked. For example, Orca locks that show a skull and cross bones when unlocked (**C**) and not when locked (**B**), or screw gate carabiners that show no color when locked (**D**), but red when unlocked (**E**).

Concept of Compatibility:

It is vitally important that carabiners be "compatible" with whatever they are connected to. Compatibility can be thought of as the "harmonious interplay of connecting components" [6], which really means the two things that are connected work well together, and thus have a lower probability of causing problems. For example, the Petzl Fixe pulley has fixed side plates and will tri-load D shaped carabiners, but loads oval and HMS style carabiners in extension (Figure 11b-d). Similarly, the carabiners used to connect racks to harnesses can be incompatible with the rack frame. If loaded incorrectly, the rack frame can lever open the carabiner gate, and disconnect the rack from the carabiner (Figure 11e,f) [13]. The incompatibility of racks with some carabiners has caused some accidents in the past [3], which has prompted some to advocate the use of screw links to connect racks to harnesses [10]. Therefore, while the concept of compatibility is a poorly known idea, it is of vital importance to rope users because incompatibility problems can result in preventable fatalities.

Because there are so many ways to connect different components, each connection should be assessed for compatibility before loading. Twist carabiners around to see if hardware can catch on carabiner gates, then ensure that as the carabiner is loaded, it is loaded correctly (in extension) with no cross or tri loading. With a little practice, this can be performed quickly, and for those connections that are made frequently, assess the equipment compatibility once, then with future connections check correct loading. For those using carabiners to connect racks to harnesses, ensure the carabiner is loaded correctly before committing your weight.

When purchasing equipment, chose carabiners that are compatible with the hardware and software you use, and carabiners that will perform adequately given their intended purpose.

Philosophy On What to Buy:

Ideally, you purchase and use the carabiners that most appropriately meet your needs. Practically that is not how we start purchasing equipment. Most of us start buying gear before we really know what we are doing, we spend decades slowly accumulating more gear as we learn more, gear improves, and we have more money. For many, our initial forays into gear purchasing occurs when we are young, so price is a large factor in our buying decisions. Given the content of this article, purchase the most appropriate carabiner(s) for your intended use giv-

Figure 11: Examples of compatibility and incompatibility of hardware. **A**) A compatible pulley and carabiner, **B**) An incompatible carabiner and pulley that torques the top bar when loaded, **C,D**) Compatible carabiner and pulley combinations that load carabiners along their long axis, and **E,F**) Example of how a carabiner gate can be levered open by a rack if the carabiner is gate loaded.

en your budget. Alternatively, use the carabiner most appropriate for the task at hand from among the limited gear you have. Often that is all you can do!

For those that have expendable cash, purchase the carabiner(s) that are the right tool for the job because there is no one carabiner that is perfect for all rigging functions! Your life, and the lives of others, is worth the extra money spent on purchasing the most appropriate carabiner(s) for a job. Therefore, a discussion of price is unnecessary. Similarly, I will not advocate for any particular manufacturer or carabiner type because all the products produced by reputable manufacturers and certified to some standard are quality products. Note that some manufacturers intentionally cater to particular markets, so have a reputation within those communities. For example, SMC makes many carabiners specifically for rescue and industrial use, while Petzl and Rock Exotica both make carabiners primarily for climbing and other sport applications. However, if you find a carabiner that meets your needs exactly, is certified to a relevant standard, and it is from a manufacturer often associated with another discipline, buy it! They are all quality products!

Here is my thought process when I start thinking about purchasing a new carabiner; obviously others may use a different process, this is simply one way to think through carabiner purchases, and is included as an example process:

1. Start with composition; do you need an aluminium (light) or steel (sturdy) carabiner.

2. Will the carabiner be used in a caustic or corrosive environment (e.g., around salt water or industrial plant?). If so, then anodizing is appropriate for aluminium carabiners, and stainless steel preferable of the steel carabiner options. Zinc or oxide coatings are also appropriate, but the coatings come off with use (e.g., abrasion, nicks, dings, scratches, etc.), so stainless steel is preferable in caustic environments.

3. Pick a carabiner shape that is appropriate for your use.

4. Pick a gate type that is most appropriate (locking/non-locking, lock type-if appropriate, straight/bent gate, etc.).

5. From the list of appropriate carabiners, pick the carabiner with the most appropriate size and weight given the intended use. Look for lower weight carabiners for backcountry applications, like climbing, backcountry rescue, caving, canyoneering, etc. In these environments, reduced weight is often an advantage.

This step by step process is easy to follow, and usually helps you pick a carabiner simply and easily. However, sometimes a few carabiners are more or less equivalent, so a couple of additional rules of thumb are useful.

1. Smaller carabiners are often desirable due to low weight, but they are generally harder to use, and perform fewer functions well (less versatile). Be aware of these limitations, so you know what you can and can not do with your equipment. If you need versatile equipment, smaller carabiners are less appropriate.

2. Larger gate openings make it easier to clip many things into the carabiner. If you tend to clip many things into one carabiner, get carabiners with larger gate openings (Offset D's, and HMS).

3. Rounder bar stock and larger diameter bar stock works better for applications when a rope is pulled over the carabiner (e.g., pull down rappels, top roping, etc.). Pick carabiners made from these bar stock types if you pull ropes frequently.

Once you have limited your carabiner search to those that have the properties you need, try them out to see if they work for you. Personal ergonomics is often just as important as other carabiner features, particularly for climbers. Make sure the carabiners fit in your hands, their action is smooth in your hands, and you can move or lock/unlock the gates easily. A carabiner good for one person is not good for another. So ideally try before you buy! Get friends to let you handle their equipment, attend classes and try others gear, or attend longer trainings (like the National Cave Rescue Commission courses).

Just remember, the piece of equipment that will protect you the most is your brain, not a piece of gear. So buy quality carabiners, but it is more important to know how to use them!

Optimal Carabiner Use:

Carabiners are only as strong as the brain that rigged them because carabiner strength is also a function of rigging geometry. Here are a few rules of thumb to improve your carabiner usage.

1. Use the right carabiner for the job! If given a choice between a few carabiners, use the carabiner with the most appropriate properties out of the choices available.

2. Carabiners are stronger when loaded along their major axis (Figure 12a), so load carabiners parallel to the long axis when possible. Cross loading or gate loading a carabiner (Figure 12b) is when it is loaded along its narrow axis (force applied to spine and gate). Carabiners are much weaker when cross loaded, so prevent cross loading whenever possible!

3. Triaxial loading, or tri-loading, is when a carabiner is pulled in three (or more) directions (Figure 12c). Because carabiners are designed to be loaded along their major axis, tri-loading dramatically reduces carabiner strength, particularly for D-shaped and Offset D shaped carabiners. HMS and Oval carabiners can tolerate tri-loading better, but all carabiners are weakened by triaxial loading. If tri-loading is unavoidable, orient the smallest carabiner end so that it is being pulled apart (Figure 12d); this is the strongest configuration if tri-loading is unavoidable [14,22].

4. Carabiners are much stronger with closed gates. After rigging double check to make sure nothing caught and kept the carabiner open (e.g., webbing).

5. Prevent gates from opening during use by locking carabiners (if possible), or facing the carabiner gate away from any object that could compress the gate. So face gates way from rock walls, the ground, limbs, or any other object.

6. When locking screw gate carabiners, screw them shut, then back them off a quarter turn so they are not impossible to unscrew when loaded. If, after loading, a screw gate carabiner it is hard or impossible to unlock, load it again, and unscrew it a little. The deformation caused during loading can often make it difficult to unlock if the locking mechanism tightens when the carabiner is deformed. If a screw gate carabiner is impossible to open even when loaded, using a piece of webbing or piece of accessory cord (e.g. prusik loop) as a strap wrench may unlock the carabiner in a pinch (Figure 13).

7. To keep screw gates locked during use, orient the screw gate down so gravity screws the locking mechanism down as the carabiner shakes when used.

8. Generally, do not overload your carabiners. Some people pull down trees, haul cars, lift heavy loads, etc. with their carabiners. While carabiners will hold (usually), they were generally designed to hold only one or two person loads. So avoid overloading carabiners if possible.

9. Avoid dropping carabiners. The available data on dropping carabiners indicates that there is little to no strength reduction when dropping carabiners even long distances, though carabiners can sustain damage to the frame, gate, and locking sleaves [5,11,25]. So it is good practice not to throw carabiners around or drop them. However, if one falls a short distance, feel free to use it. If one falls tens or hundreds of feet onto a hard surface, then it should probably be retired on principle even if no significant observable damage occurred…

10. Avoid hardware-to-hardware connections. When two pieces of hardware are connected, they can twist and apply torque to carabiner gates (Figure 11e,f). Obviously, it is common practice to clip hardware to hardware, particularly in caving, because we connect our ascenders and rappel devices to our harnesses with carabiners or screw links. So hardware-to-hardware connections are not horrible, just suboptimal, because there are greater opportunities for accidental incorrect use. When connecting hardware-to- hardware it is good to double check to make sure the components are in the correct orientations (e.g., not gate loaded or torqueing the gates) prior to loading, or use screw links which do not have gate loading problems. This is why many cavers permanently attach their rappel device to their harness with screw links, because accidents have occurred when carabiner gates were incorrectly loaded [3], or hardware not correctly connected to harnesses before use [4,10]. The best orientation for a locking carabiner to connect a rappel device is with the gate facing the rappeller (so that it will not open by compression against a sharp lip), and with the gate facing down (to keep the gate locked).

Figure 13: Using accessory cord as a strap wrench. Wrap cord around the locked gate, and pull on the strand that will rotate the gate to unlock it while holding tension on the other strand. In this case, pull on the upper strand.

Inspection, Cleaning, Storage, and Retirement:

Inspect carabiners before and after use to ensure they are in good working order. Look at and feel carabiners to ensure they are the right shape (no deformation); there are no sharp edges, nicks, burrs, cracks, corrosion, or excessive wear. If you find burrs, remove them with some fine sandpaper (220-400 grade). Ensure gate rivets are not bent or missing. Operate the gate to ensure movement is smooth and not crunchy (sand or mud in the hinge), and it closes all the way. For locking carabiners, lock and unlock the gate to make sure it is operating correctly. If you heavily use your equipment, it is a good idea to occasionally inspect your gear with a jeweler's loop to ensure there is no high cycle fatigue cracking [26]. Alternatively, you can use die tracing to locate small cracks, though this technique is only practical for people or companies with large volumes of hardware that are used frequently.

Clean carabiners if needed. Usually they can be cleaned by blowing off the dust and dirt, though they can be cleaned with fresh water and a brush if needed. Rarely will you need soapy water. After washing, dry thoroughly before storage or lubricating. Unfortunately, water and soapy water, in particular, removes lubricant in the gate and locking mechanisms. So lubricate your carabiners if you wash them with water or soap and water.

Dry lubricants are more appropriate for carabiners than liquid lubricants because dust and grit can stick to liquid lubricants, and liquids can leak out of/off of carabiners. Generally, lubricate carabiner gates and locking mechanisms when needed. Lubricate the hinge, spring hole, and locking mechanism, and then wipe off any excess. Wax based lubricants are also okay to use, but are less appropriate than dry lubricants.

Store carabiners in a dry place free from corrosive chemicals, water, humid or salty air (e.g., not in a wet bag near an ocean). Carabiners can and **should** be, labelled. This can be done by marking with a pattern or series of colors painted on the spine with nail polish, then covered with clear nail polish. Carabiner spines can also be etched/scratched without loss of carabiner strength. Marking carabiners with colored tape or heat shrink tubing over stickers will work for a short time, but these marking mechanisms tend to fall apart with repeated use. Not marking or labelling equipment is a great way to lose it after a day of rigging, so all users should at least consider marking their hardware!

There are many reasons to retire a carabiner, chief among them is that you lose confidence in it. If, for any reason, you just do not feel comfortable using a carabiner, pull it out of service. Your life, and the lives of others are worth buying a new one you trust! Retire a carabiner when they have been dropped on to a hard surface from a high location [5,11,25], the gate or locking mechanism no longer works, or it has worn through significantly. The data available on strength of carabiners relative to wear indicates that most wear locations do not dramatically reduce carabiner strength [9,19,24], so when they are worn enough to cause concern, retire them prior to reducing strength. If maintained well, most carabiners will last for decades, assuming they are not used for abrasive tasks (e.g., belaying, rappelling on Münter Hitches, etc.). So retiring carabiners should be infrequent if you are conscientious about gear cleaning and maintenance. When retiring carabiners, mark them or throw them away so no one will use them by accident. Alternatively, you can always donate them for testing by sending them to SAR3 (http://sarrr.weebly.com/).

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Literature Cited

Balance Community, 2013, An In-Depth Look at Pulley Efficiency (http://www.balancecommunity.com/slack-science/an-in-depth-look-at-pulley-efficiency/)

Ben Winston, 2012, When will your wiregate carabiner fail on you? (https://www.youtube.com/watch?v=5ilVgLH1ikI)

Bosted, Peter, 1991, Fatal Accident In Sistema Cuicateco, Mexico, Speleo Digest 1991:485-487

Bussey, Bill, 1992, A Disturbing Incident: Keep Your Rappel Rack Attached to Seat Harness While On Rope, Nylon Highway 35: 8-9

Richard Delaney, 2015, Scientific Process (http://www.ropelab.com.au/scientific-process/)

Denis, Kevin, 2012, Compatibility: Your Connection, Proceedings of the International Technical Rescue Symposium 2012

DMM, 2015, Carabiner and Bolt Interaction (http://dmmclimbing.com/knowledge/carabiner-and-bolt-interaction-vid/)

Floyd, Dug, Horrocks, Glenn, Unknown Date, How Efficient are Pulleys and Related Devices Used by BWRS in Vertical Rescue (http://www.bwrs.org.au/sites/default/files/PulleyReport/PulleyReport-w.html)

harness man, 2014, Deep groove in carabiner? (http://www.bogley.com/forum/showthread.php?73395-Deep-groove-in-carabiner/page2&highlight=testing%2C+canyoneering)

Ivy, Joe, 1999, Rappelling 101: Using an Open Frame Rack, Speleo Digest 1999:372-375

Margolis, Jim, 2015, Should You Retire a Dropped Carabiner (http://www.outdoorsafetyinstitute.com/index.php/news/single/should_you_retire_a_dropped_carabiner/)

McKently, John, 2011, Revisiting Pulley efficiency in Rescue Rigging, Proceedings of the International Technical Rescue Symposium 2011

Popall, Peter, 2003, A Little Something you Should Know About Carabiners, Proceedings of the International Technical Rescue Symposium 2003

Powick, Kolin, 2016, QC Lab: Off-Axis and Tri/Quad-Axial Loading (http://blackdiamondequipment.com/en/experience-story?cid=qc-lab-off-axis-tri-axial-carabiner-loading)

Powick, Kolin, Unknown Date, QC Lab: Weakness of Nose-Hooked Carabiners (http://blackdiamondequipment.com/en_US/qc-lab-weakness-of-nosehooked-carabiners.html)

Prattley, Grant, 2016, Pulley versus carabiner efficiency (http://oterescue.com/rope-rescue/pulley-vesus-carabiner-efficiency/)

Richard Delaney, 2015, Scientific Process (http://www.ropelab.com.au/scientific-process/)

Richard Delaney, 2016, Carabiner Gate Mass (http://www.ropelab.com.au/carabiner-gate-mass/)

Shokoples, Cyril, Neff, Morgan, 2001, Carabiner Wear and Strength Reduction in Old Carabiners, Anecdotal Test Results (http://www.rescuedynamics.ca/articles/pdfs/CarabinerWearTests.pdf)

Sheehan, Alan, 2004, Friction Testing and Pulley Systems in Vertical Rescue (http://kristinandjerry.name/cmru/rescue_info/Technical%20Rescue%20Research/Friction%20Testing%20And%20Pulley%20Systems%20In%20Vertical%20Rescue%20-%20Sheehan.pdf)

Sheehan, Alan, Howard, Peter, Young, Jim, 2004, Vertical Rescue Friction Testing (http://kristinandjerry.name/cmru/rescue_info/Technical%20Rescue%20Research/Vertical%20Rescue%20Friction%20Testing%20Of%20Pulleys%20-%20Sheehan.pdf)

Slacktivity, 2015, How the shape of a carabiner influences its breaking load (https://www.youtube.com/watch?v=g730mHDtXaA)

Smith, Gordon, 2014, Pulley Efficiency in a Rescue System, Proceedings of the International Technical Rescue Symposium 2014

Sturmberg, Bjorn, Unknown Date, Do you need to retire dropped carabiners? (https://fatcanyoners.org/bush-guide/dropped-carabiners/)

Wallace, Garin, 2000, Is It Still OK To Use? Proceedings of the International Technical Rescue Symposium 2000

Wallace, Garin, 2009, High cycle Fatigue Testing, Proceedings of the International Technical Rescue Symposium 2009

Inline Traveling Hauls: An Efficient Method of Raising a Person Up a Pitch

By Thomas Evans

Introduction:

The inline traveling haul is a technique that can quickly and efficiently raise a conscious, cooperative person up a pitch using a rope and only a little extra equipment. It requires at least some extra rope at the bottom of the pitch, and at least one rescuer/assistant. The method can be used to effect rescues with minimal equipment (Evans 2015) and personnel as well as simply to help someone who is exhausted continue a trip under their own power, thus preventing a full rescue. Thus, an inline traveling haul can be used to start a rescue sooner or prevent the need for one entirely.

Rigging:

Inline traveling hauls are 2:1 haul systems operated from below with a redirect pulley, constructed out of equipment the group carries with them (SPAR rigging kits, Evans 2015). Figure 1 shows a simple system built with equipment commonly used in sport caving. Construction requires a rope grab (any climbing hitch or ascender) with a rope redirect (pulley, carabiner, screw link) connected to the standing line, below which is the load connected to the rope by some pulley (pulley, carabiner, screw link) with progress capture. There are many configurations that will work (Figure 2), so equipment used for many hobbies will work (e.g., canyoneering, climbing, etc.). What is important is to have all the functions met: some form of rope grab and rope redirect at the top, and the haulee suspended from a pulley with progress capture. Using manufactured pulleys for rope redirects will make hauling considerably easier

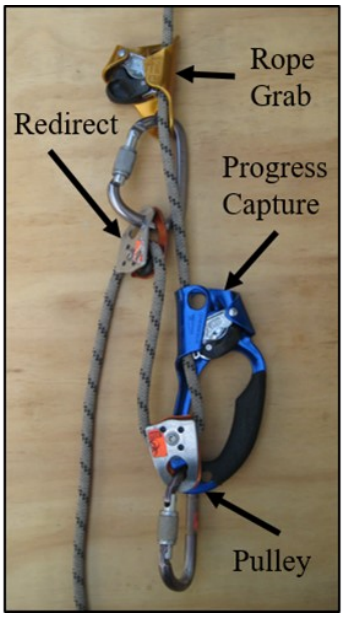
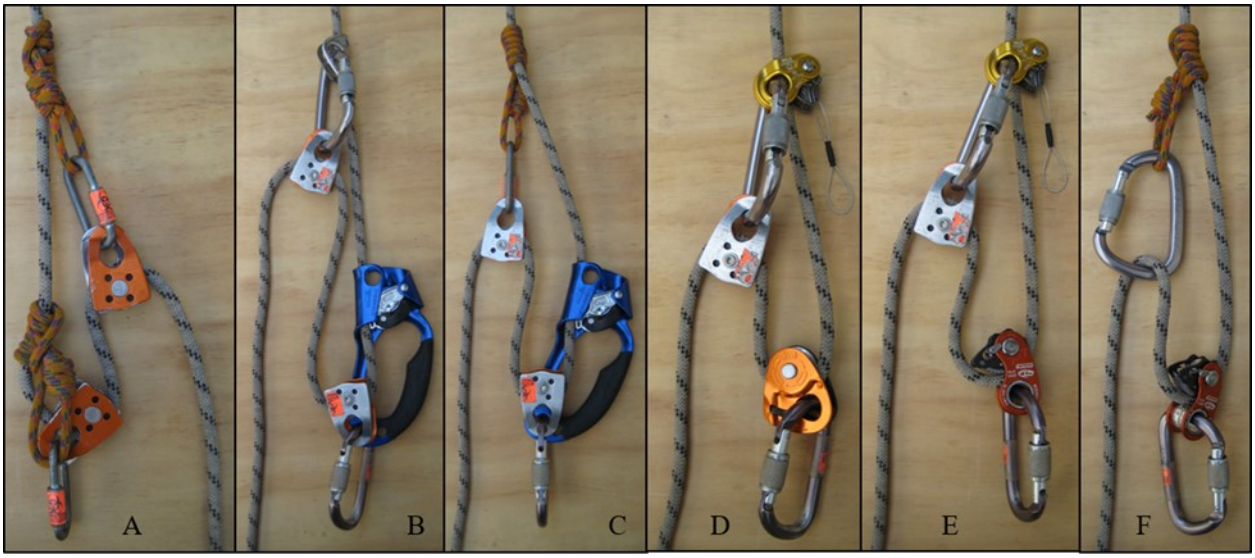


Figure 1: (Left) Anatomy of an Inline Traveling Haul

Figure 2: (Below) Example variations of the inline traveling haul. Each variation can be built using variations of a small rigging kit. As such, this method



There are four common rigging variants:

Figure 3A shows a configuration with the upper rope grab reset by the haulee when the haul system collapses. No modification to the rigging depicted in Figures 1 and 2 is required. To make this system work, enough rope is needed for the hauler(s) on the ground to reach the rope, plus an additional 2-3m (6-9ft) for the haul system itself. If the rope only reaches the ground, connecting extra webbing, slings, or cord can provide enough length as needed.

Figure 3B depicts a variant where the upper rope grab is reset by someone climbing above the person being hauled. To rig this system, connect the upper rope grab to some tether (yellow line in the figure, made from webbing, cord, extra rope, etc., Figure 4). This tether is used by the upper climber to pull the upper rope grab up when the haul system needs to be reset. This variant works much better if an ascender is used in the upper position because they are easier to pull up a rope and longer throws are possible with longer tether lengths. Because longer hauls and resets are possible, the more rope at the bottom of the pitch, the better. This is an excellent method if you rigged your rope with the extra rope on the ground and not at the anchor. Hauling will work better if the upper climber is using an efficient climbing system and stops climbing during hauling.

Figure 3C shows a simple modification of the variant in Figure 3B. The tether (yellow) can be pulled up by someone at the top of the pitch (not necessarily on the rope).

Figure 3D illustrates the most complicated version of the inline traveling haul. A climber ascends the rope between the load and the upper rope grab. This climber can reset the upper rope grab and haul on the haul system using their climbing system, or a rope grab and foot loop.

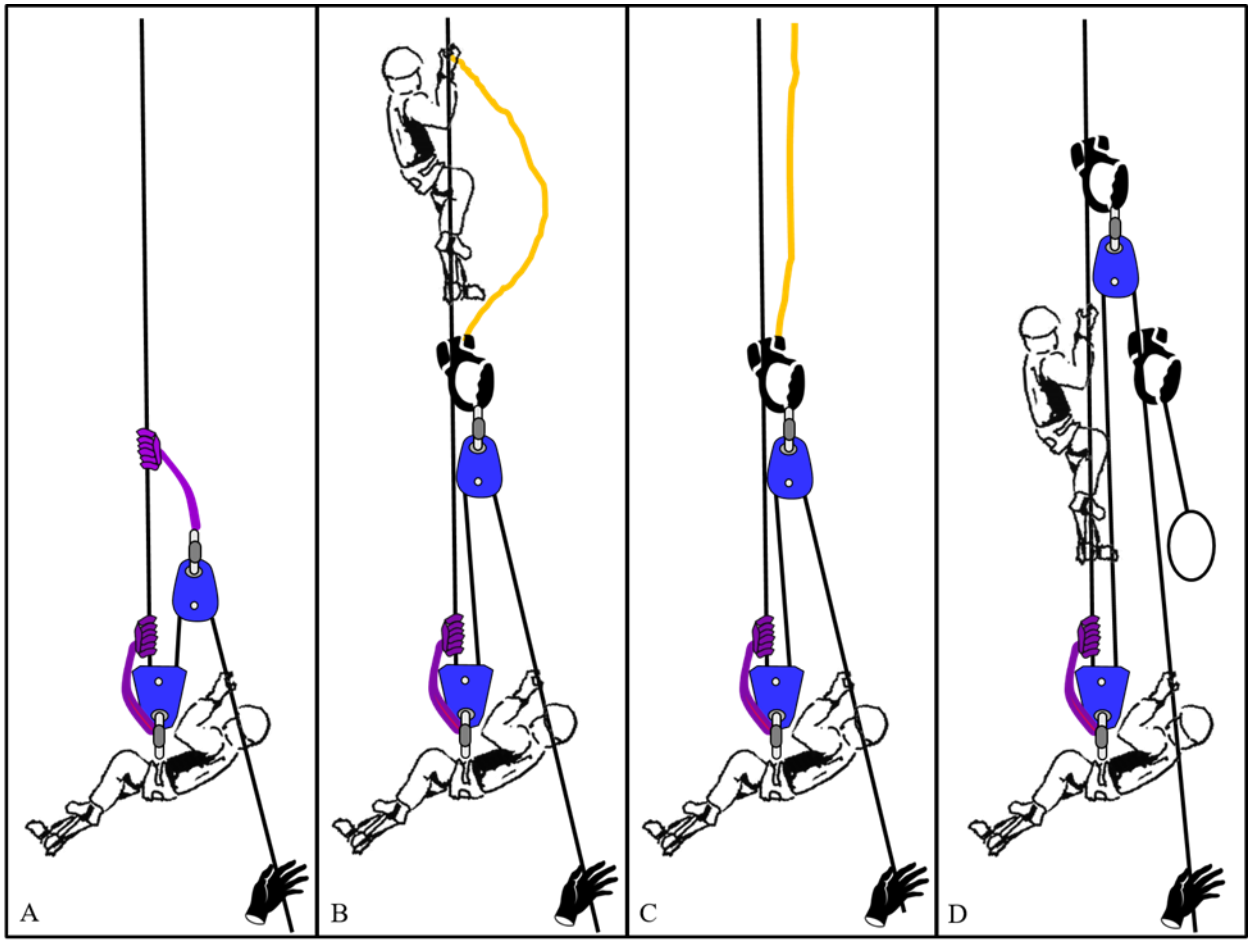


Figure 3: Four common rigging variations of the inline traveling haul (simple 2:1 mechanical advantage).

Operation:

All variants are operated similarly. The upper rope grab is pushed (Figure 3A,D) or pulled (Figure 3B,C) up the rope as far as possible, or until the haulers at the bottom can just reach the rope end. The hauler(s) at the base of the pitch pull until the haul system collapses, then they give slack so the upper rope grab can be reset. Repeat as needed. This process can be incredibly fast if you develop a rhythm! People will fly up the rope! However, if communication is bad it can be difficult because the people hauling may be holding the rope as the person above is trying to reset the system, making a reset nearly impossible. So it is vital that you have some communication system, or at the least be able to see what is going on when running the system.

This technique is particularly effective because the patient can help haul, it removes edge friction, and the haulers can effectively use their mass to counterbalance the load. The patient can assist the haul team by pulling down on the redirected rope. This makes the work of hauling that much easier, and gets the person up the pitch that much faster, without sapping hauler energy needlessly. Similarly, the rope is not moving over the edge, so the hauler(s) are not fighting edge friction, making this haul system considerably more efficient than hauling someone from the top of the pitch. Lastly, the hauler(s) can pull down with their full body weight, which makes hauling that much easier. When haul systems are operated at the top of the pitch haulers are limited in the amount of force they can add to the rope. The inline traveling haul effectively makes the hauler(s) bodies a counterbalance pulling the load up. Using a hand held ascender will make hauling easier on the hands but may create problems when resetting (the ascenders have to be removed or thumbed to reset the haul system).

If the haul system is reset from above it is important that the haul system is not extended so much that the hauler(s) at the base of the pitch can no longer reach the rope. Also, good communication between the two can be essential.

Example Uses:

This is an incredibly versatile system that can be used in a variety of environments and scenarios. Here are just a few examples to stimulate your imagination.

1. To raise a mildly injured (dislocated shoulder, broken ankle, etc.) canyoneer or caver up a pitch using the equipment already carried on a sport trip.

2. To raise a firefighter up a pitch during a technical rescue rather than ascending the rope. Often fire personnel do not practice ascending, so they must be raised up pitches during rescues. Raising fire fighters generally takes large mechanical advantage and necessitates fighting edge friction (both of which sap hauler energy), which using an inline traveling haul avoids.

3. To help raise a climber who is too exhausted or is injured get up a pitch when climbing a multi-pitch route.

4. To help a rope access technician reach a workstation when feeling tired and needing a little help to get up the rope.

Figure 4: Inline traveling haul with a tag line (red webbing) for resetting from above.

Acknowledgements:

This technique was not the author's idea. It is unknown to me who came up with the idea, but it was taught to me by Carl Amundson, and is a variant on the partner rescue method in Marbach and Tourte (2002:296-298). Sarah Truebe provided editorial assistance, but any mistakes and omissions remain entirely the fault of the author.

Literature Cited:

Evans, Thomas, 2015, Small Party Assisted Rescue (SPAR) Rigging Kit, (http://sarrr.weebly.com/small-party-assisted-rescue.html)

Marbach, G., and Tourte, B., 2002. Alpine Caving Techniques: A Complete Guide to Safe and Efficient Caving, First English Edition, Urs Widmer, Switzerland, pg. 296-298

Washington Cavers in Papoose Cave, 1960s-1990s

By Daryl Greaser

Cavers from Washington's Cascade and Xanadu Grottos were involved with the original exploration and survey of Papoose Cave that began in the mid-1960s. The following are some highlights I found while researching old newsletters. In addition, Papoose was included, replete with old map, in the 2006 NSS Convention held in Bellingham, Washington.

1965 – Labor Day weekend trip to the “Wet 40” (Butterfly's Piddle) with Bill Halliday and others. The party found can of tobacco containing the inscription “A damned fool was here.” Grotto members added “And so were 5 others.”

1966 - Dye tracing in Papoose emerged at a resurgence spring 2,100 feet lower than Papoose's entrance in an adjacent valley.

1968 - Steve Knutson is on the first trip down “Puberty Pit,” the third major drop in the mainline of the cave, which “separates the men from the boys.”

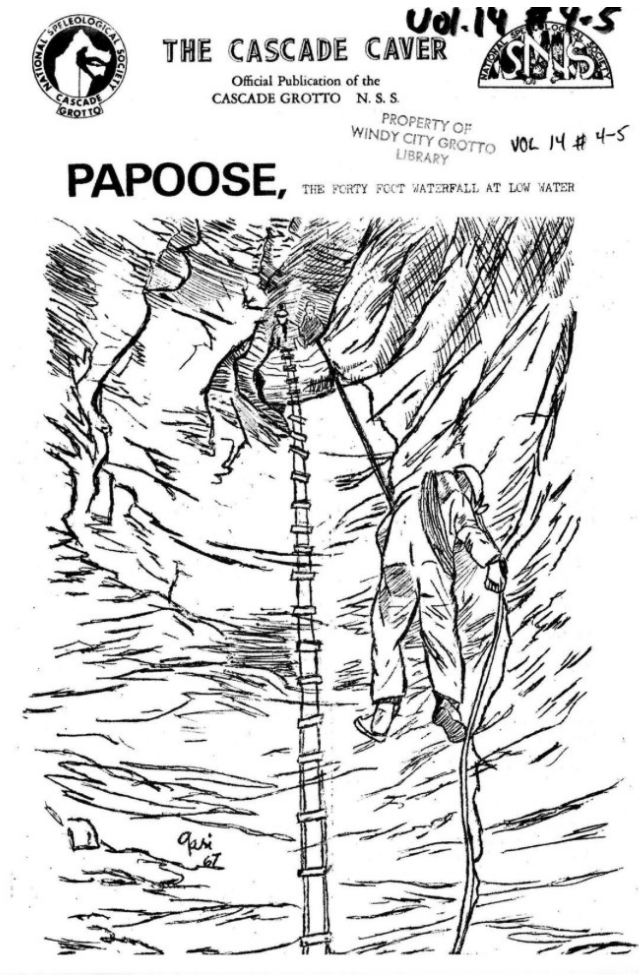
1971 - A caravan of 15 cavers leave Issaquah, WA on Friday to convene for a Memorial Day weekend trip with cavers from Idaho, Montana, Oregon, Nevada, and California attending. Trips of more than 19 cavers ensued and several “mini-conventions” are reported during this time.

1972 - First trip to the bottom past the “Rotten 50” with Tom Miller et al.

1974 - “Papoose Cave Convention in 1968” Memorial Day weekend, where 50 cavers from the Cascade Grotto, Gem State Grotto, Great Basin Grotto, Oregon Grotto, Salt Lake Grotto and the Canadian Speleological Society participated. Gas rationing was in effect: “we found a station in Auburn where we were allowed 2 gallons; enough.”

1975 - Cascade Caver cover is a drawing of the “Wet 40” in Papoose

1981 - Cascade Caver cover is a photo of Valhalla in Papoose. Report of a 1965 trip where they met Jim Specklemire, the miner who owned the claim on the cave. He set up a sluice box at the waterfall drop in the Wet Way, not finding gold, then mined some speleothems from below the first drop, which he tried unsuccessfully tried to sell to tourists.



1987 – Cascade Grotto did a 12-hour tourist trip through most known areas of the cave.

1993 – Luurt Nieuwenhuis, on the 1965 trip, writes “The History of Papoose Cave” that appears in that year's NSS Convention Guidebook, held in Pendleton, Oregon.

Multi-Grotto Trip To Papoose Cave

By Daryl Greaser

Participants:
Daryl Greaser (WA), Brian Gindling and Carl Froslie (MT), Jeff Wurst, Stephen Gladieux, Andrea Larson, and Ethan Donahue (ID).

Intro to Papoose
Papoose Cave is an 833-foot deep, 3.3-mile long cave in northwest Idaho. The cave is a true gem and a must-do for serious cavers. Papoose is replete with beautiful calcite formations, numerous waterfall drops, loop trip options, and more. Simply put, Papoose is a caver's cave.

Although most cavers have day-long commutes to the cave, the fact that it is a "roadside" cave, at least when deep snow isn't present, is a rare treat for those who love alpine river caves. The rock is unusual, grippy, and amazing.

Members of the NSS, regional grottos, and other cavers have been exploring Papoose since at least the mid 1960s. An extensive effort to explore and map the cave consisting of "Papoose Conventions" with cavers numbering 50 or more were common in the mid 1970s.

Trip Plans
As my summer caving plans to Montana's Scapegoat Wilderness were canceled due to extreme fire conditions, I was eager to get underground, so Brian Gindling (of Bozeman), and I (Seattle), conceived of a multi-grotto trip to Papoose. Conveniently, Papoose is the same distance from Seattle as it is from Bozeman, so we advertised the trip to members of the Northern Rocky Mountain and Cascade Grottos.

By time we got the crew together, I ended up being the only one from Cascade and we had three cavers from Idaho's Gem State Grotto! As it turns out, this conveniently streamlined the permit process as Jeff Wurst is the GSG Chairman and has good rapport with the "keeper of the keys," so to speak. Brian and I have both lead trips into the cave 4 or 5 times but not dealing with the required permits, liability waivers, and emergency contact forms is a rare luxury at a gated, permit-only cave. Thanks Jeff!

With enough cavers to form two teams, our team, consisting of Andrea, Brian, Carl, and myself, planned a "pull down" trip down the "Wet Way," a canyon passage that follows the stream level over many waterfalls and connects with the main passage at the 700-foot level, enabling a large loop within the cave, many of which are possible due to parallel and overlying canyons.

The Cave
On the day of the trip, we arrived to find 4-6 inches of snow on the ground. After much "FAF-ing," we finally hiked the short distance down to the cave, negotiating a sketchy hand-line on the way. By the time we got to the entrance my feet were already cold from standing around in wellies in the snow; at this point I was anxious about how cold they might get later on.

Papoose dips steeply and relentlessly - very little of the cave is in truly horizontal passage. We follow the main, sinuous canyon two rope drops before meeting at the Sand Room, a junction of passages intersecting at multiple levels.

There are two mandatory drops to get to the Sand Room. The first is called the "15 Foot" or "Ladder Drop," named after the small aluminum ladder that was fixed in place in the 60s, which required precipitous down-climbing to reach. This drop currently requires a 45-foot rope, which is because modern cavers avoid complacency that clearly afflicted early explorers. Modern technique suggests being roped up any time one is less than 6 feet (1 meter) from a drop of more than 6 feet.

Shortly beyond the first drop is a room containing both the "Wet 40" and the "Dry 50." They both have their pros and cons; The Wet being obvious, plus requiring a rebelay; the Dry requiring a keyhole, ceiling traverse while hauling your cave pack. Our team chose the Wet 40, which was denoted as the "Butterfly's Piddle" on old maps. That description, of course, is dependent on low-water conditions.

After the pit, we take the Mainline, a sinuous canyon passage, to a junction passage and the Sand Room, which contains a survival cache. Here we sign the register, grab a quick snack, and split up. Lucky for us the other team volunteered to set our rope at Puberty Pit, a short detour for them and the only pre-rigging we needed to make the loop.

The Wet Way
To our knowledge, the last group to visit the Wet Way was during another multi-grotto trip (NRMG and GSG) back in November 2000 with Andy Belski, Hans Bodenhamer, Mike Choules, Charley Wilkerson, and others (NRMG News, Issue 3, 2001). During that trip, which included rappelling the Rotten 50 in the waterfall, the group "criss-crossed," one group going down Satori, Puberty Pit, and the Great White Way to the Mill Race Room, the other going down the Wet Way; both groups exiting the cave in the opposite directions!

Shortly beyond the Sand Room, we head down the Wet Way, quickly coming upon the first waterfall of about 15 feet. We look at rigging options, all of which put us in the main flow. At first it looks like the passage is seriously going to live up to its name, but then I flopped into a pothole bypass we noticed, and on we went.

Most of the Wet Way involves stemming and chimneying to stay out of the water, which seldom is higher than boot-height except in the deepest plunge pools. My anxiety of being cold had evaporated by this point, as I was toasty warm in my PVC suite despite the 37-degree cave air and colder water.

We soon come to the first mandatory rope drop, where we will pull-down the rope afterwards, committing us to the full descent. Obviously, the first pull-down is always the worst, mentally speaking. We had to remind ourselves that this is an excellent pull-down trip, that either bolts or natural rigging could be found, and many reports stated the entire passage could be free-climbed.

Lucky for us, Carl had a full wetsuit and was therefore the first one down each of the drops, as he could take the brunt of the waterfall, on-purpose at times, and then guide us away for landing outside the plunge pools with a bottom belay which was barely necessary. There was no wiping the grin off his face, even when he fell over in one of the pools and was nearly submerged.

So, on we went, passing three more easy waterfalls. Nearing the end of the passage, I was surprised to have only topped my boots with water once - while nearly crawling. At these water levels, a wetsuit is definitely unnecessary.

The last waterfall drop into the Mill Race Room at the 700-foot level is especially nice, since you can climb though a karst window, bypassing the last waterfall and landing on top of a massive flowstone formation that fills most of the room. At this point, we leave the water until we're back near the entrance.

“The Sweat Way”
After this we go down the Rat Race and into the Lightning Passage, a dry side-passage named for formations that look like lightning bolts. The survival cache from the R&R room has been relocated here, as it is dry, has sandy floors, and is without significant wind.

Andrea negotiates a drop in the Wet Way (Screengrab by Brian Gindling)

Carl “guinea-pigs” the first drop (Photo by Brian Gindling)

Carl “mule-hauling” rope (Screengrab by Brian Gindling)

Daryl drops into Mill Race Room (Screengrab by Brian Gindling)

Daryl rappels through the karst window in Mill Race Room (Screenshot by Brian Gindling)

Trip Report: 2017 NCA Regional

By Sid Creutz

The Northwest Caving Association (NCA) regional was held from July 27-31 2017, hosted by the Vancouver Island Cave Exploration Group (VICEG). The regional took place in the Memekay region of Vancouver Island, Canada. Cascade Grotto had a strong showing at this event, including Cory Bantam, Morgan Lorenz, Eric Jorgenson, Maurice Kirejczyk, and myself (Sid Creutz).

Cory, Morgan, Eric and I carpooled together for the long journey from Seattle which involved a 3-hour ferry ride from Vancouver to Nanaimo and then an additional few hours of driving on the island, culminating in almost 20 miles down gravel logging roads as we traveled deep into the forest. We arrived at the camp area late Thursday; while the camp is really just a stretch of grass alongside one of the roads, it also featured a number of amenities including two wooden outhouses, and a stream that functioned as a beverage cooler. Another cool innovation was a magnetic board that we used to keep track of where everyone was and make sure everyone made it safely back from their caving trips. And, of course,

Top left: The caver-tracking board. Top right: Riding in style to a nearby cave in the back of a pickup truck. Bottom left: The camp kitchen tent. Bottom right: Night-time activities in the camp. Photos: Eric Jorgenson.

there were a lot of caves nearby, including one right at the campsite called Marble Arches, which we went to go explore almost as soon as we arrived.

Because the caves were nearby and mostly relatively short, we were able to visit at least 2-3 caves every day we were there, including:

Top left: Eric near one of the Scallop cave entrances. Top right: Inside Scallop. Bottom: Entrance to Scallop. Photos: Eric Jorgenson.

- Marble Arches: This cave was right by the campground and features some nice sinuous passageways with some fun climbing spots and a short through-trip/loop that can be completed between two neighboring entrances.
- Scallop Caves: The Scallop cave system is well-named for the beautiful scalloped rock that occurs throughout its three sections (Upper, Main, Lower). The main section is the longest and is a through trip that crosses under the road. At one end there was a flooded passage that we thought might have a duck-under allowing us to pass through, so we came back on our last day with wetsuits to explore it—but alas, it was completely sumped.

- Emilia Creek: The main section of Emilia creek was the most extensive cave that we visited, consisting mainly of a long, scalloped, and water-filled sinuous passageway. Two nuisance drops early on are navigated with webbing handlines. If you want a challenge, it's possible to avoid almost all of the water by stemming between the walls—but for the most part we avoided only the deepest parts and splashed through the rest. Close to the end there is a large room covered with small formations included stalactites and helictites. There is a pit with a 40' drop down a waterfall towards the end of the cave—this is optional since it doesn't go too much further after the drop, but it's enough to be worth visiting if you have the gear.
- Erica 2: A very small cave just around the corner from camp featuring a short nuisance drop and some small formations. This was the first vertical cave for a few of the people we brought to this cave.
- Windy Pit: A nice vertical entrance pit with some passageway at the bottom. We ended up not having enough time to fully explore this one, unfortunately.
- Great Falls: Cool cave right by the river—more extensive than we initially expected, and has a large room with a very cool waterfall!
- Fishy Hole Cave: This muddy, multi-drop vertical cave was a bit of an adventure since only one person at the regional had been to (almost) the bottom of it before and he didn't really remember any of the details of rigging or rope lengths. We rigged four fairly substantial drops off a combination of natural anchors and a bolt that had been placed at one of the trickier spots. At the bottom of these drops we found an amazing, thundering waterfall in a beautiful room featuring very sharp rock along the walls. We could see that the cave continued down another drop, but due to not having enough rope and worries about hypothermia

Top left: Cory with some formations in Emilia Creek. Top right: Nuisance drop in Emilia Creek. Bottom left: Drop into Windy Pit. Bottom Right: Exploring some entrances along the creek near Great Falls. Photos: Eric Jorgenson and Sid Creutz.

Treasurer's Report

By Talon Swanson

Seasons greetings from your Treasurer! As we wrapped up the official fiscal year for the grotto on September 30, 2017, I thought now would be a good time to recap our financial situation:

		Cash	Checking	Savings	PayPal	Total
9/30/16	Ledger	Unknown	$1,098.86	$5,059.48	$0.00	$6,158.34
9/30/17	Ledger	$107.50	$775.53	$5,059.95	$39.12	$5,982.10
Net Gain / (Loss)						($176.24)

Overall, the grotto's financial situation is relatively stable, but not great, as we had a net loss of funds over the course of the year. This is made worse by the fact that there was an unkown amount of cash-on-hand on 9/30/16 which is not accounted for in the math (i.e.- any cash on-hand on 9/30/16 would only increase the net loss).

Looking at the numbers in depth, our biggest expense for the 2017 fiscal year was certainly the rental of the room at the Tukwila Community Center ($600) followed by the PO Box ($106) and the contribution for the holiday party ($100). Other expenses for web hosting and merchandise procurement were nominal (~$60 total).

These costs were offset by the 35 dues paying members who contributed $525.79 in membership dues. Since there were no documented monetary donations and since merchandise is priced only at the break-even point, there was no other income for the grotto in 2017.

Moving forward, cash is now being fully accounted for, so there should no longer be any discrepancies in the financial numbers. Merchandise is also going to be inventoried so that its value may be properly accounted for as well. Another recent change for us has been the addition of a PayPal option for paying membership dues. This option has already started off strong with 7 of the 2018 renewals to-date having been paid using this method.

65 Years Ago: 1952

By Daryl Greaser

- The Cascade Grotto was 1 year old.
- Field trips to Granite Falls and “Mt. St. Helens caves” were described.
- Each of the 11 grotto members were also members of The Mountaineers; 9 were NSS members.
- The first two “Mount Snoqualmie Caves” were located and partially explored in July 1952 by Thomas and Anne Steinburn. A small cave on what we now call “Cave Ridge” was reported to them by Robert Clark. In late September of that year, Thomas returned with George Adair to continue exploration. Although they were able to push slightly farther into the caves, going was tough, describing them as “overgrown rabbit holes,” requiring physical modification for continued caving.

Cascade Grotto Officers

Madeline Schaller, Chair

Sid Creutz, Vice Chair

Talon Swanson, Treasurer

Mariana Tomas-Savage, Secretary

Cascade Grotto Meetings

The Cascade Grotto meets on the third Friday of every month from 7:00 to 9:00 pm.

Our meeting location is currently Arts Room B in the Tukwila Community Center, which is located at 12424 42nd Ave S, Seattle, WA 98168.

Cascade Grotto: Enjoying and conserving caves in the Pacific Northwest and beyond since 1951.

Contact Us

Give us a call for more information about us, our trips, meetings, and members:

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