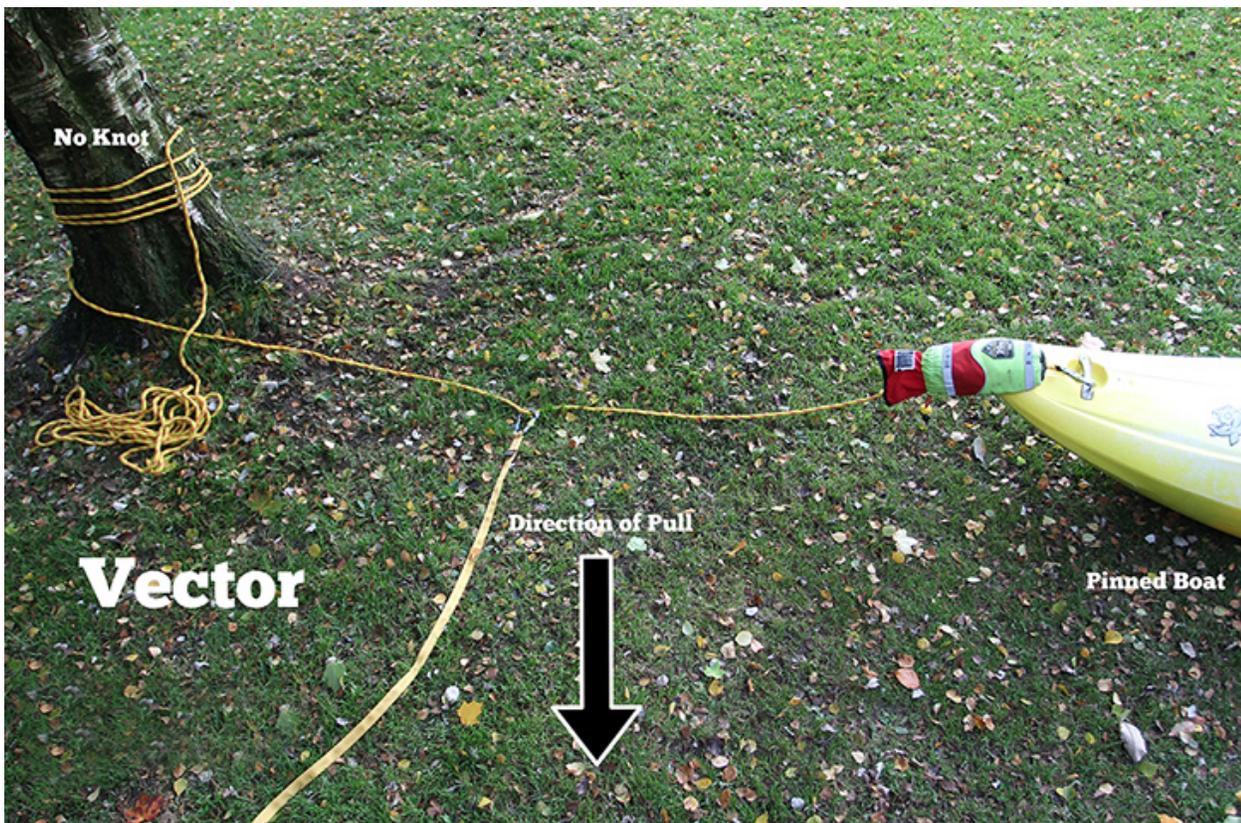


### Using a Vector Pull and Mechanical Advantage (Z-Drag)

Quite often, the power of the river makes it impossible to free a pinned boat with just the strength of one person. In these situations, vector pulls and mechanical advantage (sometimes referred to as a “Z-Drag”) systems can be used to substantially increase the pulling force.

A vector pull is quick<sup>1</sup> and easy to set up, and great for situations where you don’t have the right equipment to set up a Z-drag. Tension the rope as much as possible, and then tie it off (a tree is best). Pulling on the center of this tensioned line at a ninety-degree angle will create a vector that multiplies the force at the load (which is the boat, since the tree isn’t moving!). The best way to do this is to add a second line onto the middle of the tensioned line. The second line is the one you pull on.



Mechanical advantage – we’ll keep this simple by looking only at the most basic Z-drag, a 3:1 mechanical advantage system. The general idea is that by redirecting the free end of a loaded rope through an anchored point (a pulley is the most effective) and then back again through another pulley attached to the main line, it multiplies the effect of your pulling on it. The 3:1 ratio indicates that a system such as this multiplies the pulling force by three. For example, if you can pull with a force of 100 newtons (N), this system would allow you to exert 300 N, minus some small amount due to friction.

<sup>1</sup> Whitewater Kayaking The Ultimate Guide 2 nd Edition by Ken Whiting and Kevin Varette

To set up a 3:1, you'll need to draw from your rescue kit. Wherever we indicate the use of a pulley, a carabiner can be used as a replacement – it's just not as effective because it creates a sharper bend and more friction in the line. The first step is to make an anchor. This is usually as simple as wrapping a piece of webbing (or a sling) around a sturdy tree or rock and attaching a carabiner to it. For a stronger anchor, you can double wrap the webbing, but make sure it's not too tight. Remember our vector pull? Well, this applies to anchors as well. If you wrap the sling too tightly, then pulling on it can act as a vector pull and unnecessarily multiply the forces being applied to the anchor. Also, position the webbing so that the knot or seam holding the ends together is away from the carabiner that will be loaded.

Once the anchor is ready, attach a pulley to the carabiner, if you have one, and feed the rope into it. Now, attach a prusik as far back down the main line as possible. Today, you can buy pulleys that have a prusik function built into them, which is preferable because they are much faster to set up; and prusik cords can create enough friction heat to melt the sheath on a polypropylene rope. If you don't have either a prusik cord or a mechanical prusik, you can use an overhand knot to create an attachment loop. However, this is not the best set-up as you'll have to untie and retie it as you pull the rope in; and any knot in a loaded line presents a weak point. Attach a pulley at this point along the main line and feed the rope into it. You know you are on the right track if you are pulling on the end of the rope in the same direction as the main line is pulling on the load. This makes sense, since you should have made two directional changes in setting up the system. Et voila, you've created a Z-drag, just like that!

This technique has the capacity of tensioning the line to dangerous levels. By hanging a wet skirt or PFD over the loaded line, you can reduce potential recoil hazard if the line did ever break. One other safety consideration is that whenever you use a system such as this, the load is securely attached to the rope with no quick-release system. Always have a plan for after the victim or equipment is pulled free.



**Keep it simple:** It's a Z<sup>2</sup>. The 3:1 drag works but positively baffles people. Let me explain it like this: imagine you have a 100-pound bucket of cement. When you grab the handle you will struggle to lift it, as your arm is lifting all 100 pounds. But if a friend grabs on the handle too, you will each be lifting 50 pounds. Add another arm and you each lift a third, or 33 pounds. Three arms split the work in three, or create a 3:1 system. Flip this logic around: three arms can do three times the work of one; more arms multiply the force.

The physics are the same for the Z drag. Even though there is only one handle on the boat, the three parallel lines are like three arms pulling, splitting the load and multiplying the force.

The Z shape is what matters, as it gets three lines working together. The other parts of the system – the sliding prusik and pulleys – just keep the arms equalizing so they can all do their third of the job. The 60-Second Z-Drag. You will need a 5-70 foot throw rope, prusik, two carabiners, two pulleys (you can use carabiners) and a sling.

- 1) Build an anchor by wrapping the sling around a sturdy tree or rock. Clip a carabiner and pulley through the sling
- 2) Secure the bag end of the rope to the load. Run the tail end through the anchor pulley

3) Wrap the prusik loop as far back down the ropes toward the load as possible. Clip the second carabiner and pulley through the prusik

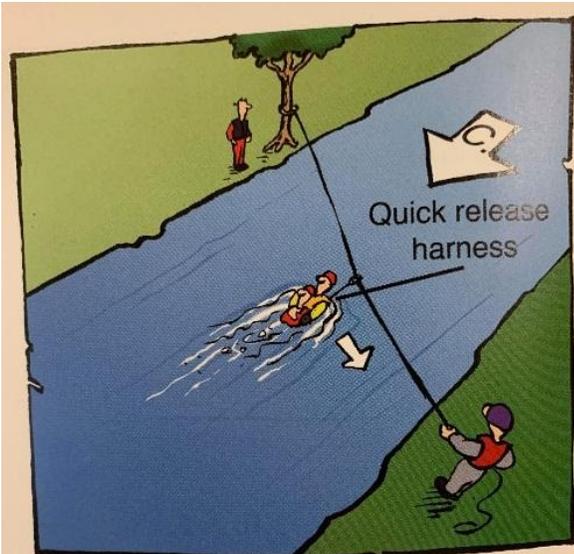
4) Run the tail end of the rope through the prusik pulley and back toward the anchor. Pull on the tail end of the rope in the same direction as the main line is pulling the boat. You now have a Z drag.

## Using a Tag Line to Rescue a Victim

Some hydraulics are strong enough to hold you even when you come out of your boat. Rescuing victims from these “keepers” can be a high-risk affair, even on a tether. The water is very aerated, so you don't float very high in it. Along with this, the turbulence and recirculating flow make it hard to both breathe and get oriented, and there is the risk of becoming entangled in the rope. If the victim is unconscious, you have no choice but to swim to them. If he is conscious, however, and the location permits, you can use a tag line to reduce risk.

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<sup>2</sup> Whitewater Kayaking The Ultimate Guide 2 nd Edition by Ken Whiting and Kevin Varette



A diagonal line allows a rescuer and victim to safely cross the river while using the river's current to do the bulk of the work.

A tag line<sup>3</sup> is a rope tensioned across the river or channel that has been walked upstream on both sides until it reaches the victim. It offers stability and possible escape route. To establish it, either two people can hold it across the water and walk upstream, or it can be tied off (upstream of the victim) on one side and walked up on the other. In a hydraulic situation, the line would be kept at water level and walked up to the victim in the hole. Once the victim has grabbed hold of the tensioned line, there are several options to get him out of the hole. Probably the most sensible is for the rescuers to pull one end towards the desired bank while line is gradually let out at the other end, allowing the victim to be pulled right into shore. With this in mind, if you're tying one end off to establish the tag line, make sure it's on the same side that you plan to pull the victim into. As with all other rescues, a contingency plan should be in place in case something goes wrong. It's always a good idea to have safety set up below rescue location.



A tag line can be useful to extract conscious victims from sticky holes.

### Using a Tag Line to Stabilize a Pinned or Entrapped Victim

A tag line can also provide crucial stabilization in some vertical pin or foot entrapment situations. In a vertical bow pin, the bow of the victim's boat is lodged in an obstruction and the force of the water hitting the victim's back can make it impossible for them to get out of the boat.

<sup>3</sup> Whitewater Kayaking The Ultimate Guide 2<sup>nd</sup> Edition by Ken Whiting and Kevin Varette



Similarly, in a foot entrapment situation, the victim's foot is lodged in an obstruction and the water is forcing them downstream with too much power to overcome. For either one, the idea is to get the tag line under the arms of the victim and then lift the line and stabilize them in a position that allows her to breathe and possibly free themselves from the entrapment. Often just stabilizing them will give them the ability to wiggle free. If not, a decision must be made based on the circumstances about whether to go to them and help.