

TECHNIQUES FOR INSTALLING  
A RESISTANCE BOARD FISH WEIR



By

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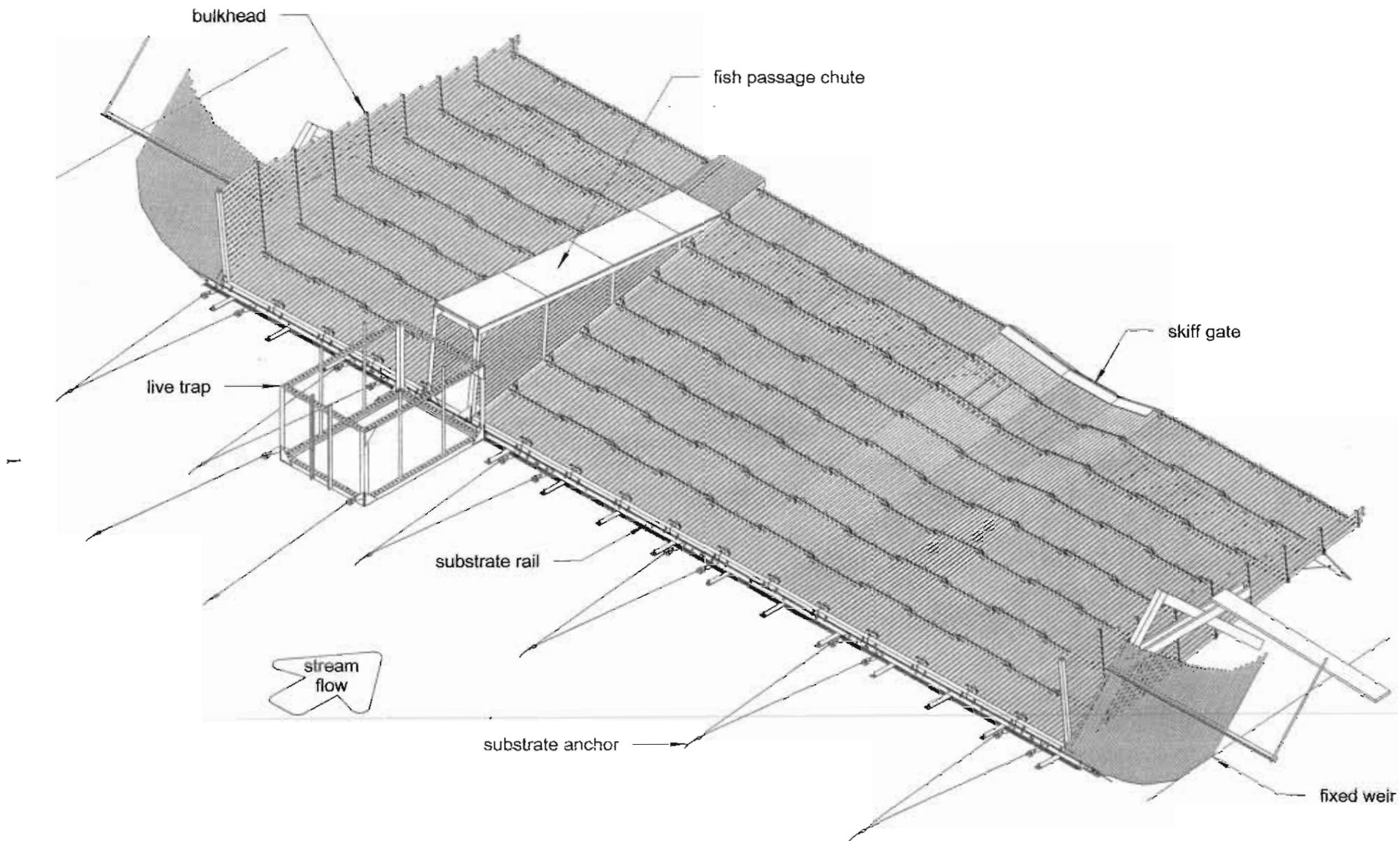
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## ABSTRACT

The use of resistance board weirs to count adult salmon migrating in rivers has dramatically increased in recent years. Alaskan fishery managers and researchers are converting to this design as a flood resistant alternative to traditional weirs and counting towers. This manual has been written to document methods and guide users in the installation of resistance board weirs. It describes current techniques used by the Alaska Department of Fish and Game to install weirs in the Kuskokwim Area, and will be relevant to all weirs of similar design. Included are step-by-step instructions for the installation of a substrate rail, methods for installing weir panels, and tips on weir removal and storage.

**Key Words:** fish weir, fish fence, floating weir, resistance board weir, substrate rail, weir panel



**Figure 1.** *Resistance board weir*

## INTRODUCTION

The use of resistance board weirs to count adult salmon migrating in rivers has dramatically increased in recent years. Alaskan fishery managers and researchers are converting to this design as a flood resistant alternative to traditional weirs and counting towers. This manual was written to document methods and guide users in the installation of resistance board weirs. It describes current techniques used by the Alaska Department of Fish and Game to install weirs in the Kuskokwim Area, and will be relevant to weirs of similar design elsewhere.

The resistance board weir consists of two principal components: weir panels form the barrier, and a substrate rail anchors the panels to the river bottom. Other components include passage chutes to allow fish passage through the weir, bulkheads and fixed pickets to prevent fish from passing around either side of the weir, modified boat passage panels to allow boat traffic over the weir, and a trap to collect data from live fish. The rail is anchored to the streambed across the width of the channel. Each panel is a 3' wide array of 1" by 20' long tubular PVC pickets. Each picket is sealed at both ends for flotation. One end of the panel is attached to the rail and the other end floats to the surface downstream. The action of stream flow against an inclined resistance board mounted beneath the downstream end of the panel lifts this end above the stream surface. When attached side by side along the rail, panels form the face of the weir. During flood conditions, panels are forced below the water's surface, allowing debris to pass unobstructed over the weir.

Installation is considered in three parts: the substrate rail, weir panels, and a section on removal. Work may begin as soon as river conditions allow. Crew must be able to wade the site to work effectively. Drysuits and snorkel gear are used to improve wading capability and complete underwater tasks. This manual defines wading conditions as *normal* when an individual can reasonably wade a perpendicular course across the channel in a drysuit, and *difficult* when an individual is not able to wade a perpendicular course but is able to maintain steady contact with the bottom.

The rail must be completely installed before proceeding with installation of panels and other components. Rail installation requires normal wading conditions, but panels can be installed during higher water in difficult wading conditions. For this reason the rail is often installed before the operational period and left installed during the winter months. But because winter and spring ice conditions can be destructive, this strategy only works at sites with moderate coastal winters without thick ice. If normal wading conditions can be anticipated near the beginning of the operational period, the best strategy is to remove the rail after each field season.

## RAIL INSTALLATION

The substrate rail system includes the apron, rail assemblies, rebar stakes, duckbill anchors, and cables, and must be completely installed before proceeding with the installation of panels and other components.

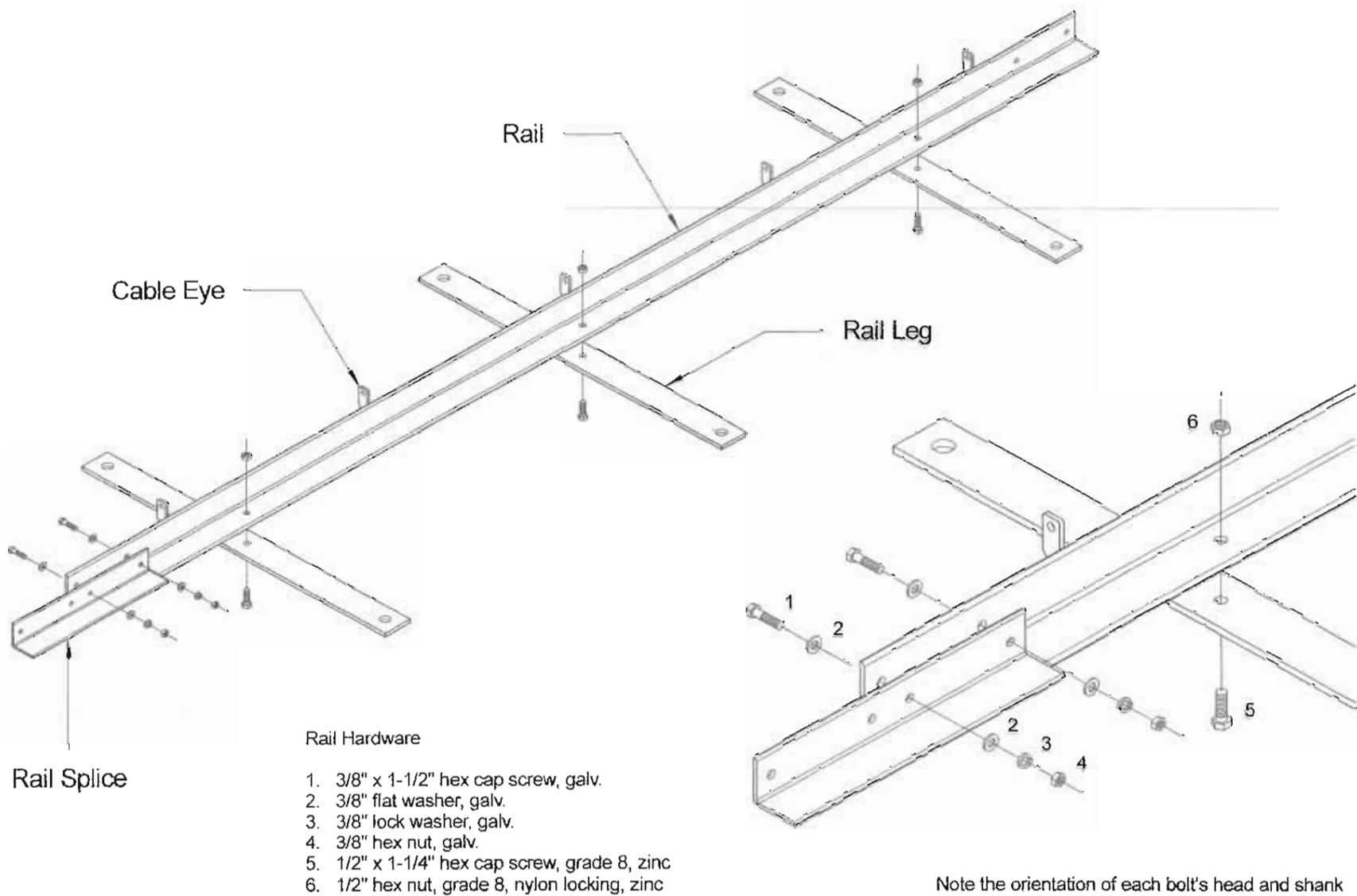
At the start of rail installation, a guide wire is hung taught across the channel several feet above the water surface. A 50' section of substrate apron is positioned beneath the guide wire and 10' rail sections are installed over it. Each section of rail is aligned with the guide wire before it is staked to the bottom. Duckbill anchors are driven upstream with strainer cables leading back to support the rail in the event scouring undermines the stakes. A 3/8" cable is threaded through each rail eye across the channel and tensioned to provide an attachment structure for the weir panels. If the weir has not been installed before, then sections of rail and apron may need to be assembled first.

### *Assembling the Substrate Rail and Apron*

If the rail sections and substrate apron have already been assembled, then proceed to the section on installing the guide wire.

#### **Rail Assembly Instructions:**

1. Bolt the three rail legs to the 10' rail section (Figure 2).
  - Tighten the bolts just enough to allow the legs to pivot by hand.
2. Bolt the rail splice to one end of the 10' rail section (Figure 2).
  - The splice may be bolted to either end so long as it is bolted to the same end consistently on each rail.
  - Tighten the bolts just enough to flatten the lock washer. Do not over tighten these bolts! Excessive tightening will not make the splice any stronger and may damage the threads. The splice is designed to slip vertically when bolted to the rail. This design allows the rail to conform better to the irregular river bottom.

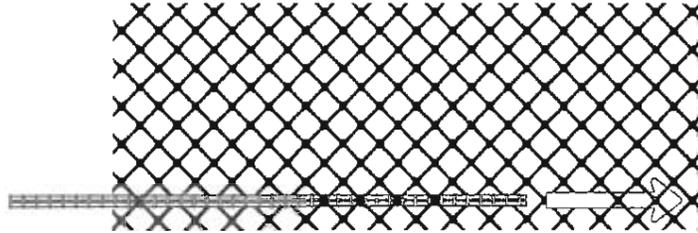


**Figure 2.** *Substrate rail assembly*

### Apron Assembly Instructions:

The substrate apron is used to keep the gravel in place beneath the rail. It is made of 50' lengths of black polyethylene mesh, 48" wide. Ten foot lengths of ½" rebar give the mesh rigidity and weight for installation in swift current. The apron is usually installed in 50' lengths, but may be cut shorter to accommodate installation.

1. Unroll the polyethylene mesh on a nearby gravel bar and cut off the tightly curled end with wire cutters. Use rocks or logs to keep the mesh flat.
2. Attach rebar along both sides of the apron by threading the rebar through every 4<sup>th</sup> mesh, one full mesh in from the margin (Figure 3).
3. Tie each 10' section of rebar to the mesh in at least 3 places with bailing wire or plastic cable ties.



**Figure 3.** *Threading rebar into the margins of the apron material*

### *Installing the Guide Wire*

A length of 1/8" cable is suspended across the channel several feet above the water as a guide for positioning the rail beneath. **Never leave the guide wire up without someone present to signal boaters.**

### Instructions:

1. Wade the entire site to determine the best line across the channel.
  - The rail should extend along a level bottom, perpendicular to the swiftest flowing portion of the channel. Trail an ore downstream as you wade to best indicate the direction of flow.
  - Small humps and depressions along the bottom can be managed, but steeper bars or channels must be avoided. Each splice allows the rail to deflect about 1.5° up or down, a difference of only 3" over 10'. However, the rail doesn't

need to conform perfectly to the bottom. Small gaps between the rail and bottom can be filled with gravel or sandbags.

2. Stretch the guide wire from bank to bank along the selected course.
  - Let the 1/8" cable sink to the bottom as you feed it out across the river so it will not drag in the current.
  - Use a come-along to tension the cable, and take out most of the sag. The guide wire should be suspended two or three feet above the surface.
  - Tie flagging tape periodically along the guide wire to make it visible to boaters.
  - **Never leave the guide wire up without someone present to signal boaters.** Loosen the guide wire and allow it to rest on the bottom during extended work breaks.
3. Level the bottom, if necessary, by kicking or raking the gravel directly below and several feet downstream of the guide wire.

### *Installing the Substrate Apron*

The apron is laid on the bottom in 50' sections. If river conditions are low and wading is easy, three to five people can manage the apron. In swifter current, steel pickets are driven into the substrate at 10' intervals across the channel to assist the waders. The apron may be cut into 20' and 30' sections if only 3 people are available for installation. Once a section of apron is placed securely on the river bottom, rail is installed over it before the next section of apron is placed.

#### **Instructions for slow current:**

1. Carry the 50' section of apron into the river "Chinese dragon" style with each person carrying a 10' section of apron over head.
  - Each person brings along a rebar stake to anchor the apron to the bottom.
  - As the apron is brought into place, each person positions him/herself just upstream of the guide wire and the apron is lowered to chest level beneath the wire.
2. Sink the apron to the river bottom and step on it simultaneously to hold it in place in the current.

3. Adjust the position of the apron beneath the guide wire and temporarily anchor it with rebar stakes.
  - The upstream edge of the apron should lie about 4" upstream of a line plumb with the guide wire.
  - Push stakes into the gravel with a circular motion until each is secure. The stakes only hold the apron temporarily until the rail is installed on top.
4. Proceed to rail installation.
5. Overlap the next section of apron about one foot with the last.

### **Instructions for swifter current:**

To position the apron in swifter waters, steel pickets are driven into the gravel at 10' intervals beneath the guide wire. Each steel picket is a 7' section of 3/4" schedule 40 steel pipe, commonly used as fixed weir material. The pipe is small enough to fit through the 1-1/4" mesh apron yet rigid enough to support the drag of the wader in the current. A portion of each picket extends above the stream surface so the wader can hook the upstream edge of the apron over the top of the picket and slide it to the bottom.

1. Use a fence post driver to drive the first picket five feet out from where the apron will begin.
  - Use a rod level to stand the picket vertical about 1 or 2 inches upstream of the guide wire. If a rod level is not available, a carpenter level may be used along the upstream or downstream edge of the picket.
  - You may need to place the fence post driver on top of the picket before you position it.
  - Drive the picket into the gravel bottom until secure. A portion of the picket should extend above the water's surface. The wader must be able to pull the edge of the apron over the top of the picket.
  - The picket should be driven as close to vertical as possible.
2. Drive the next four pickets the same way, ten feet out from the last along the guide wire.
  - Use a pre-measured length of string or cable to span the 10' between pickets.
3. Carry the 50' section of apron into the river "Chinese dragon" style with each person carrying a 10' section of apron over head.

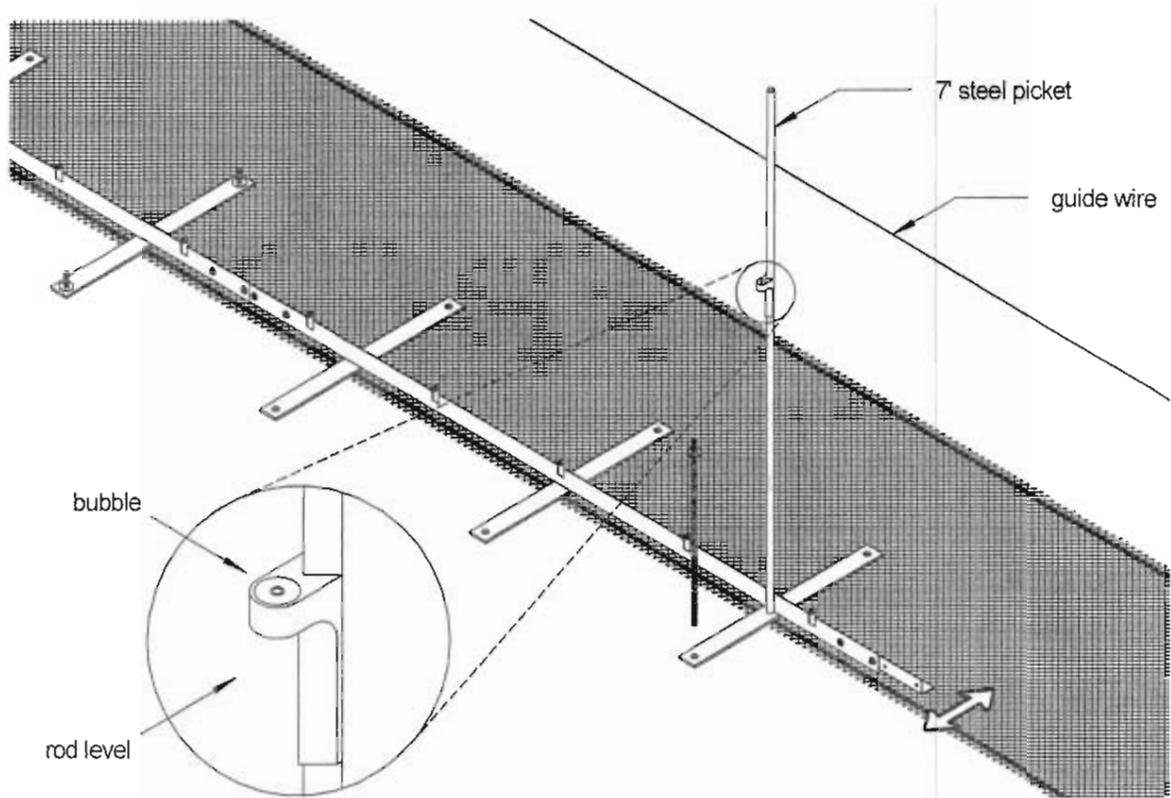
- Start well upstream so waders can get to their respective pickets before being carried downstream by the current.
  - Lift the apron over the pickets and let the downstream margin rest in the water
4. Hook the apron over the pickets and slide it to the river bottom.
    - Hook each 10' portion of apron over the picket near the lateral center of the 10' length of rebar on the apron's upstream margin, so the apron is supported by the rebar when lowered into the current.
    - The crew must push the apron to the bottom simultaneously.
  5. Install the next section of apron only after rail has been installed over most of the last section.
    - Overlap each section of apron about one foot.

### *Installing the Rail Sections*

The rail sections are aligned beneath the guide wire, bolted end to end, and staked down on top of the apron.

#### **Instructions:**

1. Align the rail section directly beneath the guide wire using a rod level and a long straight picket (Figure 4).
  - If a rod level is not available, a carpenter level may be used along the upstream or downstream edge of the picket.
  - Set the rod (steel picket) against the upstream edge of the rail on top of the farthest leg out, and move the end of the rail until the rod is plum against the guide wire (Figure 4).
  - Each rail section should be aligned with the guide wire before it is staked to the river bottom. Stream current can deflect the unstaked end of the rail several inches downstream. If this deflection is carried over each time a rail is added, the rail will soon be well off course.
2. Drive the two stakes in the farthest leg by hand.
  - Use a slide hammer with a stake driving head, or a sledge with an extension to reach underwater.



**Figure 4.** *Aligning the rail using a rod level*

- Drive the upstream stake first.
  - Adjust the position of the apron beneath the rail, if necessary, before driving the downstream stake. The upstream margin of the apron should extend a few inches upstream of the rail.
3. Bolt the next rail to the last one.
    - Use a steel rod or long spike to align the bolt holes.
    - Have one person align and insert the bolts while a second person manipulates the other end of the rail until the bolts are fitted.
    - Tighten the splice bolts only enough to flatten the lock washers. Excessive tightening will not make the splice any stronger and may damage the threads.
  4. Repeat these steps until all the rails are installed with 2 stakes each.
  5. Drive the remaining stakes with a gas powered rock hammer, if available.

### *Installing the Duckbill Anchors*

The duckbill anchors are driven a minimum of 10' upstream of the rail at each splice (Figure 5). A two-man team is needed to operate the gasoline-powered rockhammer.

#### **Instructions:**

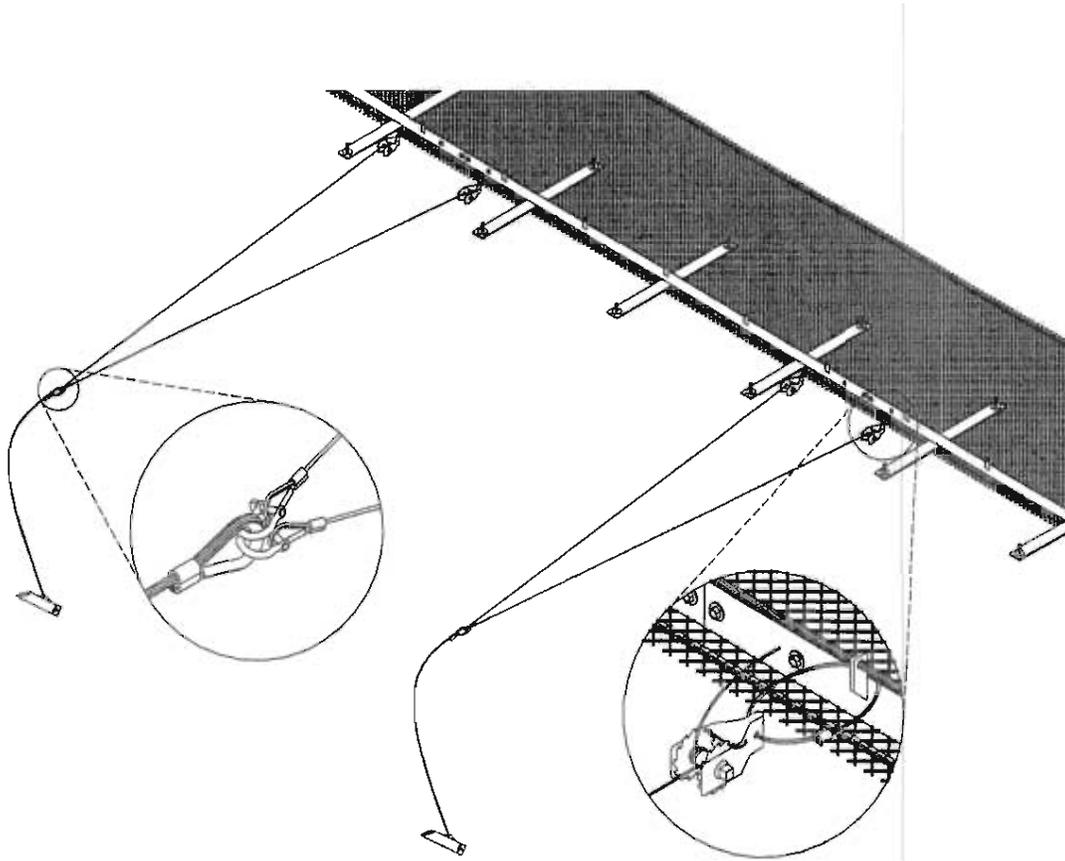
1. Attach two lengths of stainless steel duckbill strainer cables to the eye of each duckbill anchor using either one 3/8" shackle or two separate 1/4" shackles (Figure 5).
2. Locate the spot where the duckbill is to be driven by stretching the strainer cables upstream from the rail splice.
3. Assemble the duckbill, 5' driver, and rockhammer horizontally. Set the duckbill anchor in position and stand the whole assembly up vertically.
4. Pull start the rockhammer and drive the duckbill into the gravel vertically. Stop the motor when the rockhammer begins to enter the water.
  - Do not let the rockhammer's exhaust go below the water surface.
5. Release the rock hammer from the driver and install an extension to continue driving the duckbill.
  - Do not pull the driver out until the duckbill has been driven to its full depth.
6. Once the anchor has been driven to its full depth, use a pair of locking pliers to twist and remove the driver from the gravel.

### *Installing the Cable and Duckbill Strainers*

A 3/8" thick cable runs the length of the rail and serves as an attachment point for the weir panels. This cable also locks the duckbill strainers onto the rail (Figures 5 and 6).

#### **Instructions:**

1. Place a pair of ratcheting cable strainers on each rail eye adjacent to a rail splice (Figure 5).
  - Orient the strainer to face the wire bale up (Figures 5 and 6).

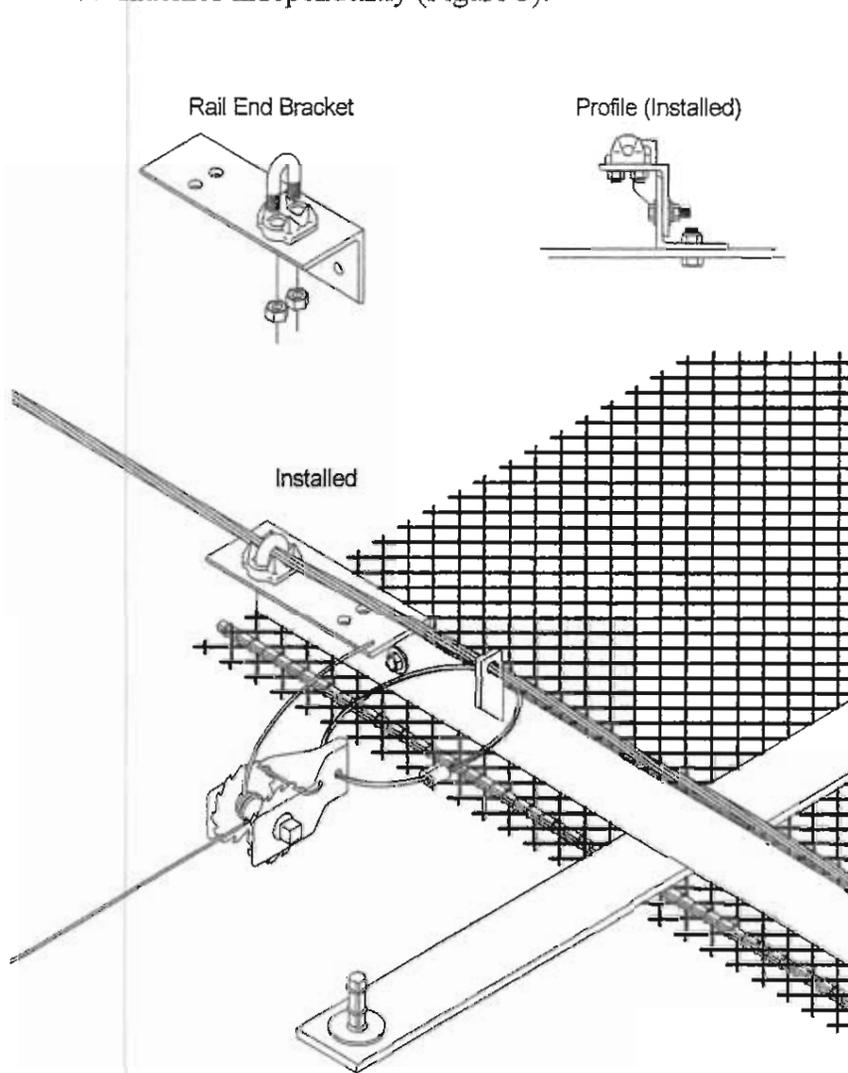


**Figure 5.** *Installing the duckbill strainer cables*

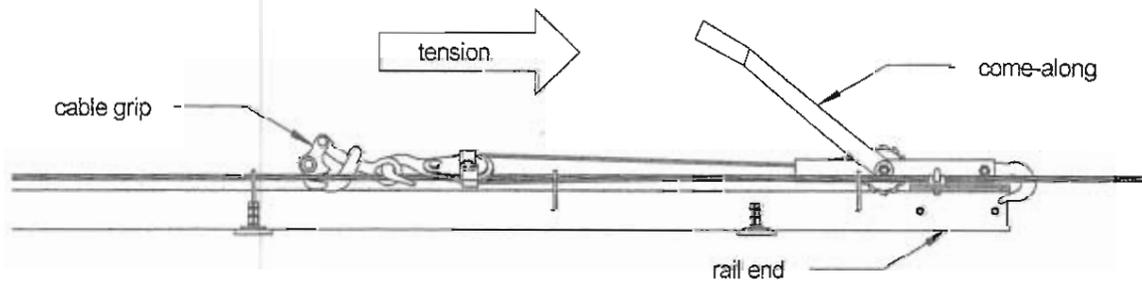
2. Feed the 3/8" cable through all of the rail eyes.
  - Wrap several layers of duct tape around the end of the cable to prevent fraying.
3. Install rail end brackets at both ends of the rail. The rail end bracket is a simple piece of steel angle that bolts onto the rail end and provides a means of fastening the cable for tensioning (Figure 6).
4. Fasten one end of the cable at the rail stop using a 3/8" cable clip.
  - Do not over tighten the cable clip, because this will kink and weaken the cable.
5. Tension the cable from the other end using a come-along and cable grip (Figure 7).
  - Do not over tension the cable. The purpose of tensioning the cable is to keep it straight when the panels are hooked to it. Increasing the cable tension does not make the rail any stronger.
  - The cable should be tight enough to deflect less than 1/2" if you step on it midway between two cable eyes.

6. Feed the stainless duckbill strainer cables into the ratcheting strainers and tension each one so at least two wraps of cable are around the spool (Figure 6).

- Attach both cables to the duckbill eye with a single 3/8" shackle, or use two 1/4" shackles independently (Figure 5).



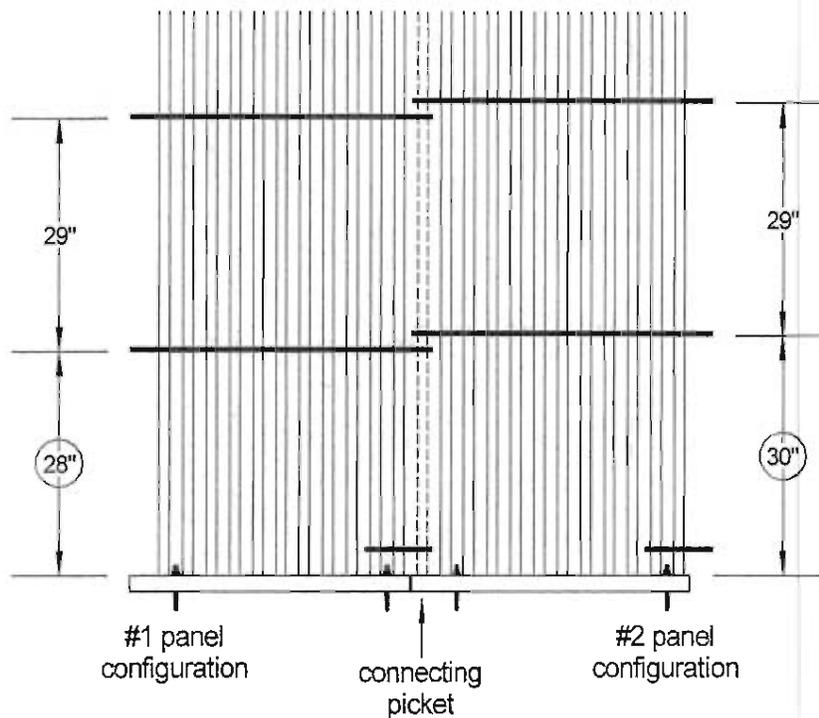
**Figure 6.** Rail end bracket



**Figure 7.** Tensioning the substrate cable

## WEIR PANEL INSTALLATION

A crew of three to five persons is required to install the panels. Drysuits and snorkeling gear are required for at least three crewmembers, unless stream conditions are relatively low. Once the rail has been prepared and the cable properly tensioned, panels are brought into the river and hooked to the rail. After each panel is hooked to the rail, it is connected to the last by threading a picket between the two. The panels are installed alternately between #1 and #2 configurations so the stringers of one panel are offset 2" from an adjoining panel (Figure 8). The #1 panels have white end caps, while the #2 panels have end caps painted red.



**Figure 8.** *Alternating stringer configurations*

### *Substrate Rail Inspection*

If the rail has been left in the river over winter, it will be necessary to clear the rail of debris, inspect it for damage, and tension the cable.

#### **Instructions:**

1. Clean any debris stuck to the rail and any gravel covering it.

- If debris is choked between the cable and rail, it must be cleared to straighten the cable when tensioning.
2. Inspect:
- Cable eyes; if cable eyes are bent they can be straightened using a large crescent wrench.
  - Cable for kinks or fraying; replace if necessary.
  - Duckbill strainers; replace if damaged.
  - Major damage to rail sections: replace each 10' section as necessary.
3. Tension the cable using a come-along and cable grip (Figure 7).
- Do not over tension the cable. The purpose of tensioning the cable is to keep it straight when the panels are hooked to it. Increasing the cable tension does not make the rail any stronger.
  - The cable should be tight enough to deflect less than ½" if you step on it midway between two cable eyes.

### *Handling Weir Panels*

A single panel weighs more than 100 pounds and can be quite awkward to carry. PVC pickets are prone to break if the panel is not handled properly, especially out of the water.

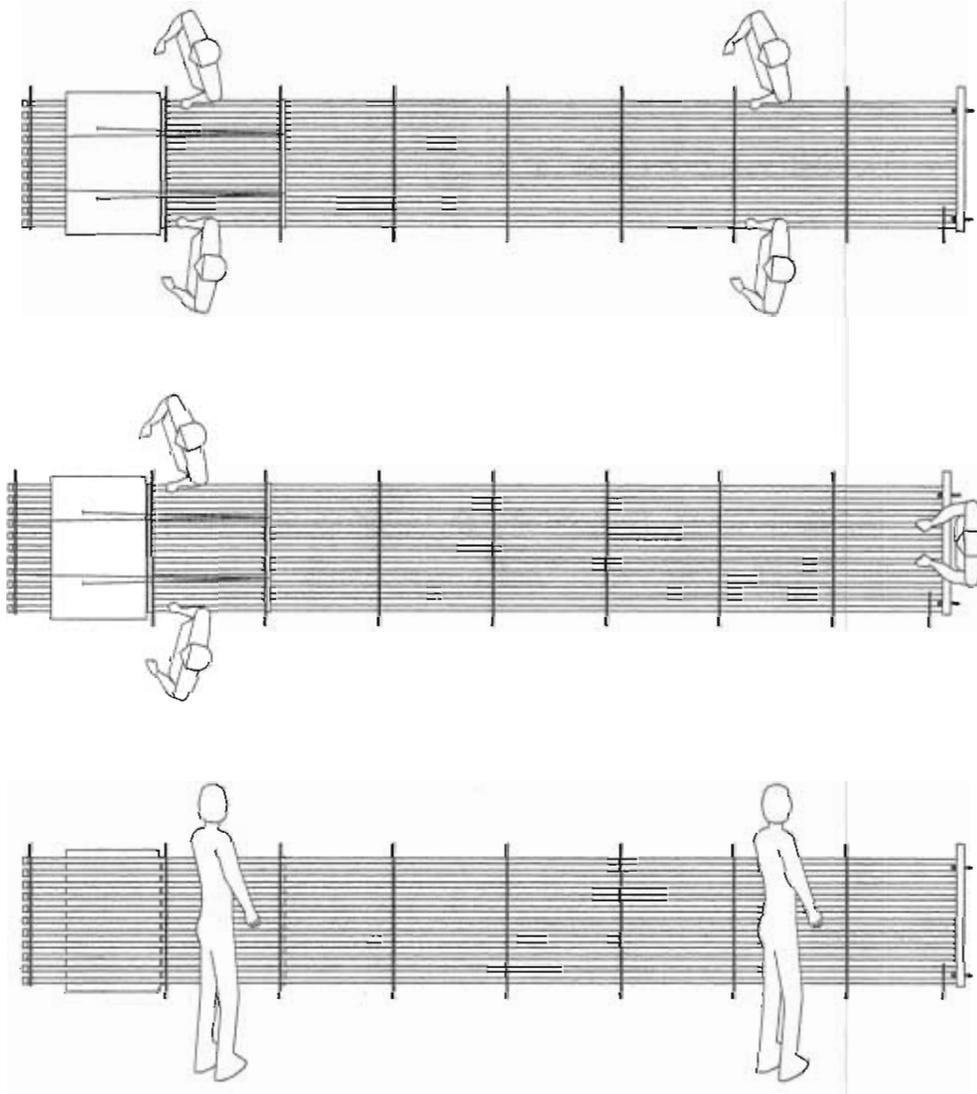
#### **Carrying and Stacking:**

- Use 3 or 4 people to carry a panel flat and level with the resistance board side facing up; alternatively 2 people can carry a panel on edge (Figure 9).
- Ensure the bottom panel in a stack is level and free of obstructions beneath that might cause damage as more panels are added to the stack.
- Stack panels to alternate the #1 panels (plain end caps) with the #2 panels (red end caps).

#### **Launching From a Skiff:**

- Stack as many as 6 panels in a skiff facing the resistance board side up.

- Ensure the resistance board cables are configured properly and clear of snags.
- Flip the panel over from one side to land it in the water right side up with resistance board underneath.



**Figure 9.** *Carrying panels*

### **Launching From Shore:**

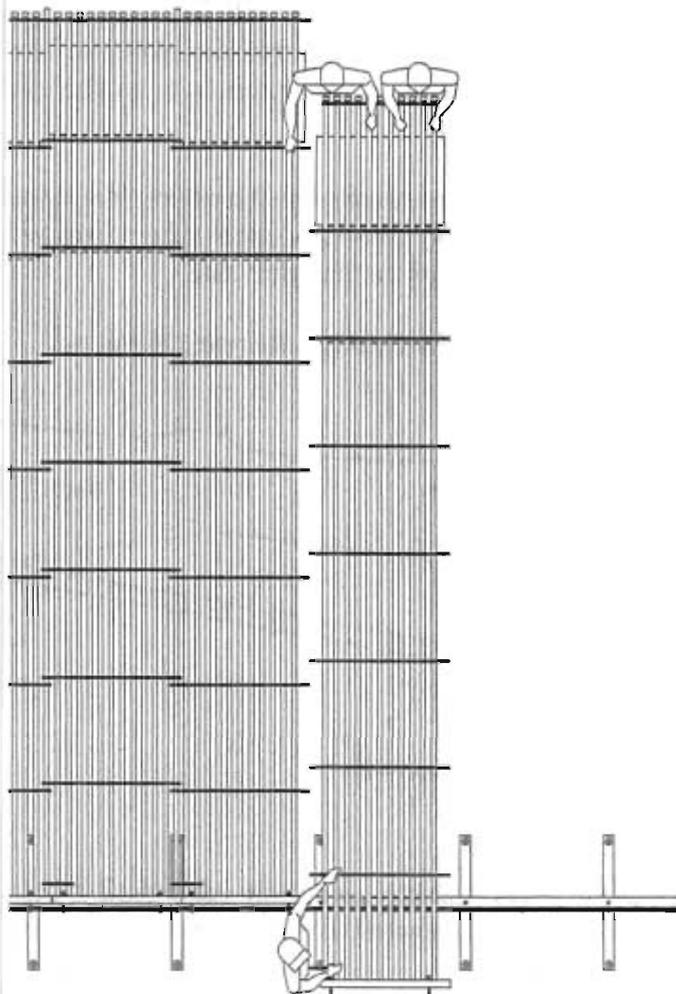
- Carry the panel into the water before flipping it over
- Ensure the resistance board cables are configured properly and clear of snags.

### Maneuvering the Panels in the Current:

- Start an appropriate distance upstream of your destination
- Lift some of the panel out of the water. This will reduce drag and give you more weight for traction in heavy current.

### *Hooking the Panels to the Rail*

In extremely slow or shallow water, one person simply guides the panel into position, submerges the base and hooks it to the rail. In stronger current two or more people are required (Figure 10). Waders at the downstream end of the panel hold it against the current, while a snorkeler at the base attaches the hooks to the rail.

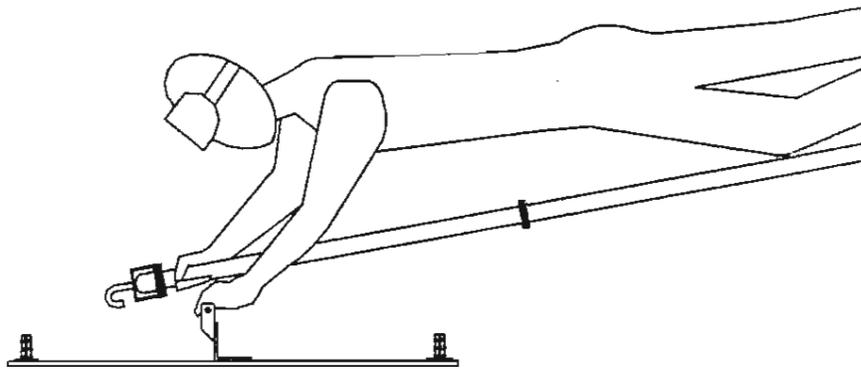


**Figure 10.** *Waders in position to hook a panel to the rail*

## Instructions:

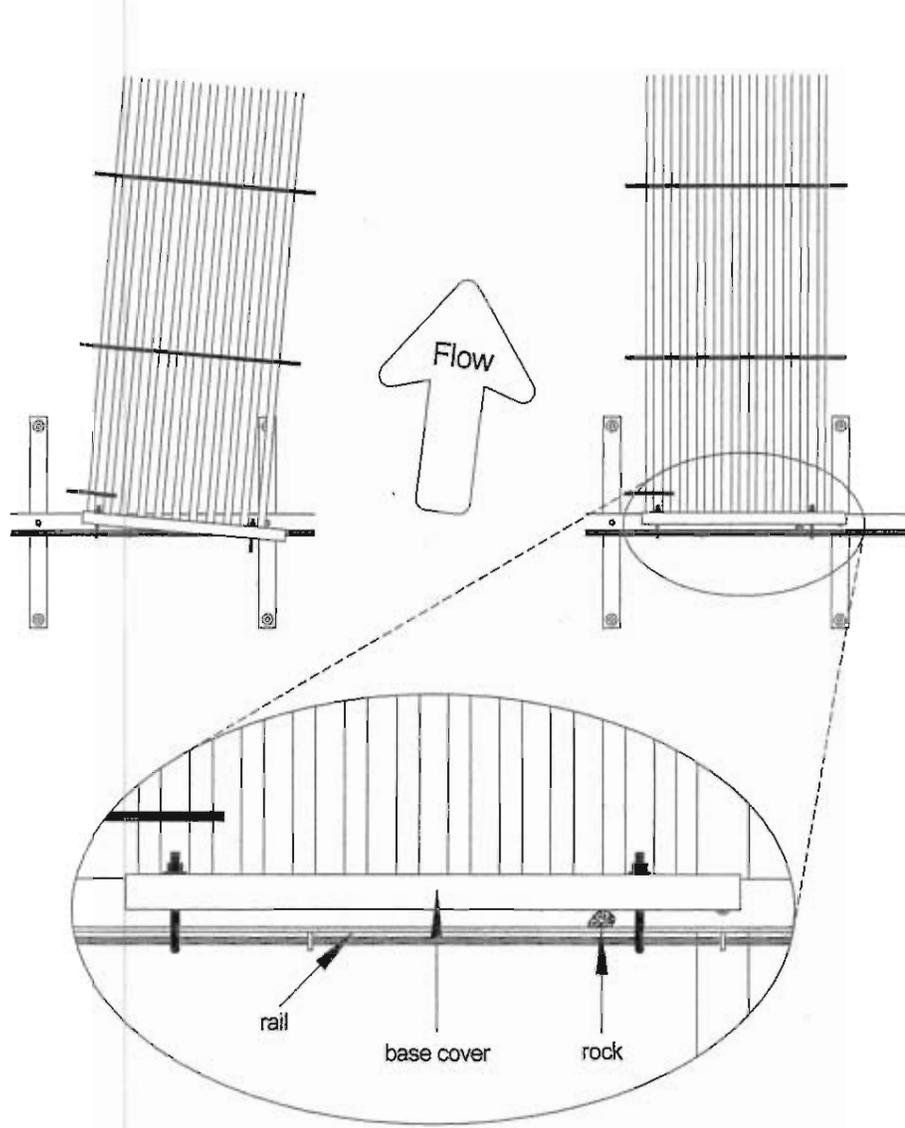
1. Float the panel into position so the base is a few feet upstream of the rail. One or two waders hold the panel in the current while a snorkeler positions at the rail (Figure 10).
2. Submerge the base, ease the panel downstream, and hook the base to the cable as it passes over the rail. Use hand signals to communicate since snorkel gear gets in the way.
  - As the snorkeler reaches into the water, he/she becomes more buoyant, incurs more drag, and often loses traction with the bottom. Waders at the end of the panel must hold the submerging panel and snorkeler in the current. One wader can brace by hanging on to the adjacent portion of weir already attached to the rail. The waders must give the snorkeler a few seconds to position underwater before letting the panel drift back, but not so much time the snorkeler runs out of breath.
  - The snorkeler pushes the base under with one hand and grabs the substrate rail with the other, letting his/her body trail downstream. The snorkeler must hold the base somewhat level with the bottom to hook the cable as the base passes over the rail (Figure 11).
  - Often only one hook gets attached to the cable. The panel is flexible enough to have a wader push only the unhooked side upstream enough to attach it without releasing the hook on the other side.

**Figure 11.** *Snorkeler hooking the panel to the rail*



3. Slide the base of the panel sideways along the cable until it butts against its neighbor to ensure the panels can be connected with a picket.
  - If a cable eye prevents the panel from sliding over, push only the affected side of the panel upstream of the eye and slide the hook past it.

4. Jam a rock between the base cover of the panel and the rail to prevent angular current flow from detaching one of the base hooks (Figure 12).



**Figure 12.** *Dealing with angular flow*

### *An Alternate Method for Hooking Panels in Swift Water*

Boats have often been used to maneuver panels when swift current makes wading difficult. This exercise usually ends in frustration because the boat drive can't see what is going on underwater. A better method uses a cable laid across the channel to guide panels into position (Figure 13). The cable lies on the bottom, upstream of the rail. A panel is tethered from the cable by a line allowing a single snorkeler to control both the panel and him/herself in the current.

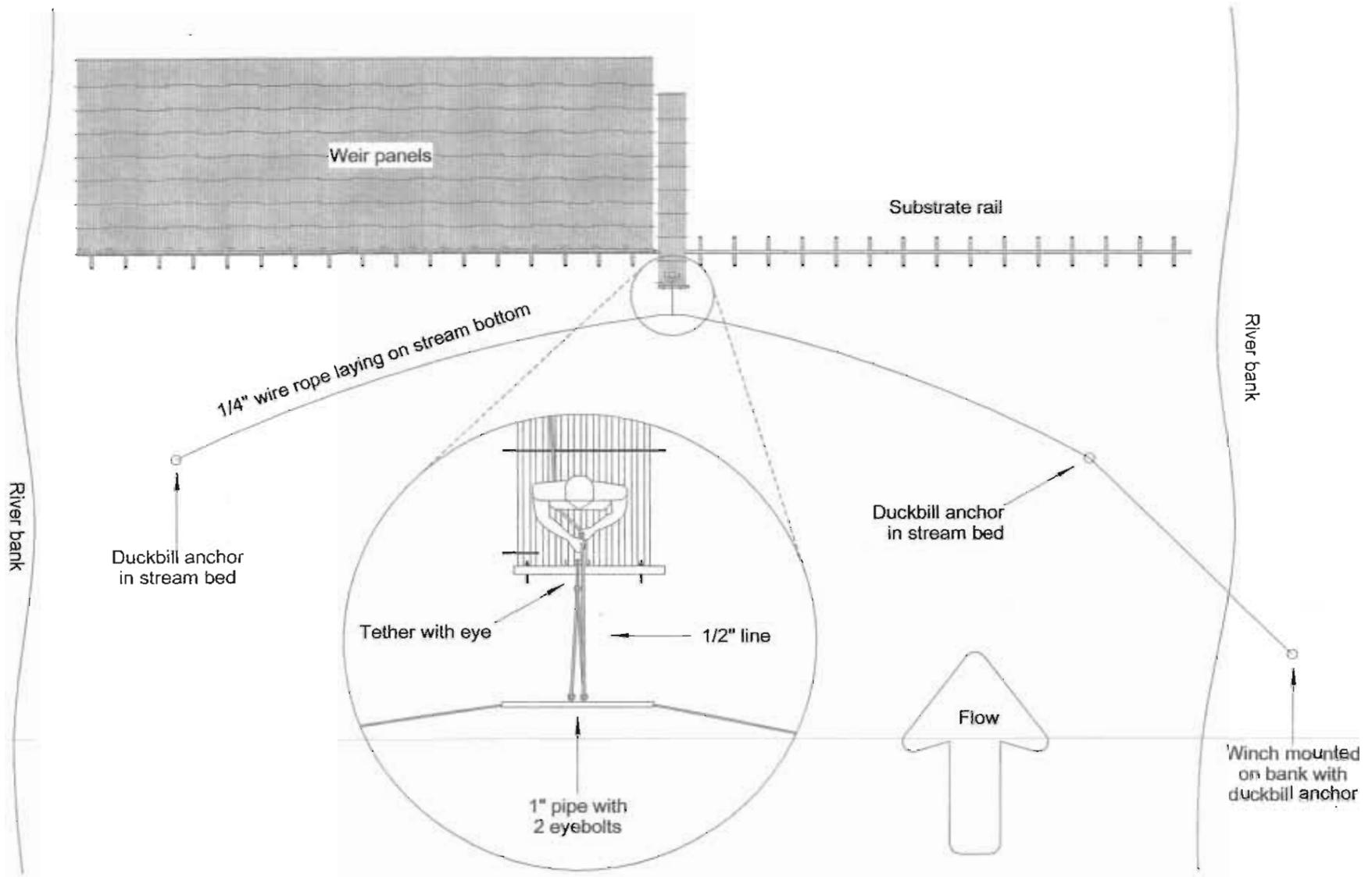


Figure 13. *Installing Panels with a Cable and Tether System*

## Instructions:

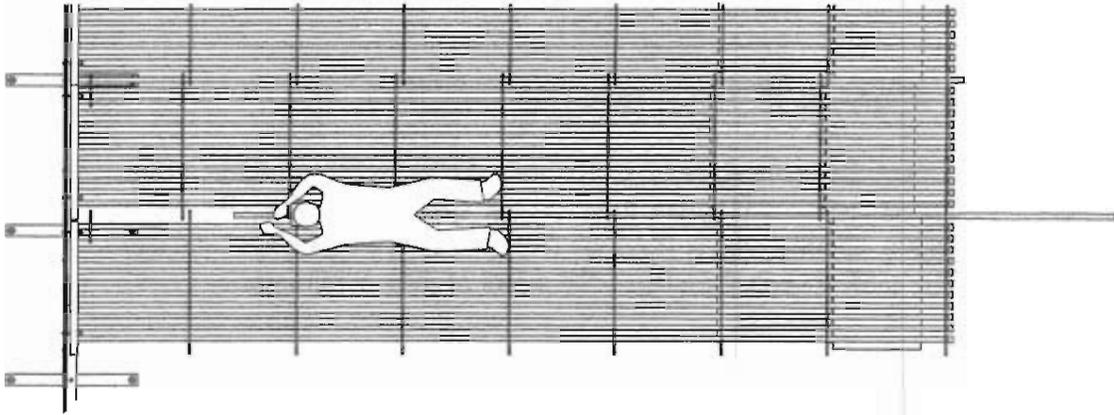
1. Install a ¼" cable as shown in Figure 13.
  - Leave the cable slack on the bottom. An unnecessary amount of tension would be needed to straighten it across the span of the river. By not tightening the cable, its only load is from the current's drag on the panel and snorkeler. Since the cable lies on the bottom the effect of drag is minimal.
  - A winch is attached to the system to adjust the amount of slack in the cable.
2. Tether the panel from the cable, as shown in Figure 13, and slide the panel across the current into position upstream of the rail.
  - The panel is tethered in slower water near the bank.
  - A wader can walk the panel across the channel using the tether to hold him/herself in the current.
3. Let the panel downstream and hook it to the substrate rail.
  - The snorkeler simply stands on top of the panel just behind the base, pushing it to the bottom. As the line is let out, weight can be shifted between both feet to hook the panel to the rail.

### *Threading the Connecting Picket*

Do not set the resistance boards while installing the connecting picket. Setting the resistance board causes the panel to bend, making the picket harder to thread.

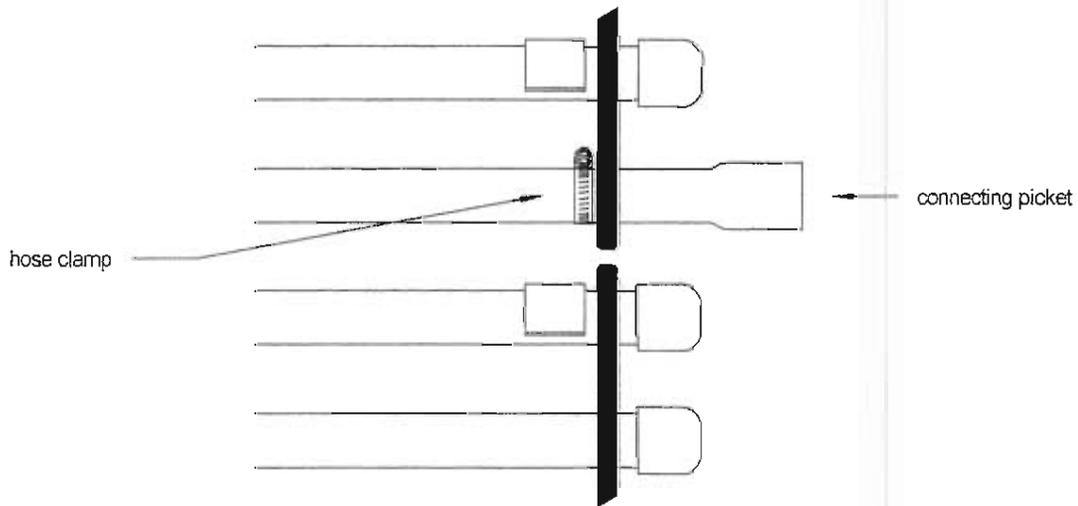
## Instructions:

1. Insert a connecting picket through the end stringer and place a hose clamp over the end before threading it through the rest of the stringers.
2. In low or slow water, simply reach over the panel from the side to thread the picket.
3. In high or fast water, snorkel over the gap between panels using the stringers as rungs of a ladder to climb upstream as you thread the picket (Figure 14).
  - In strong current, the gap between unconnected panels may be difficult to close. Have an assistant push the panel from the side as you thread the picket.



**Figure 14.** *Connecting picket hose clamp*

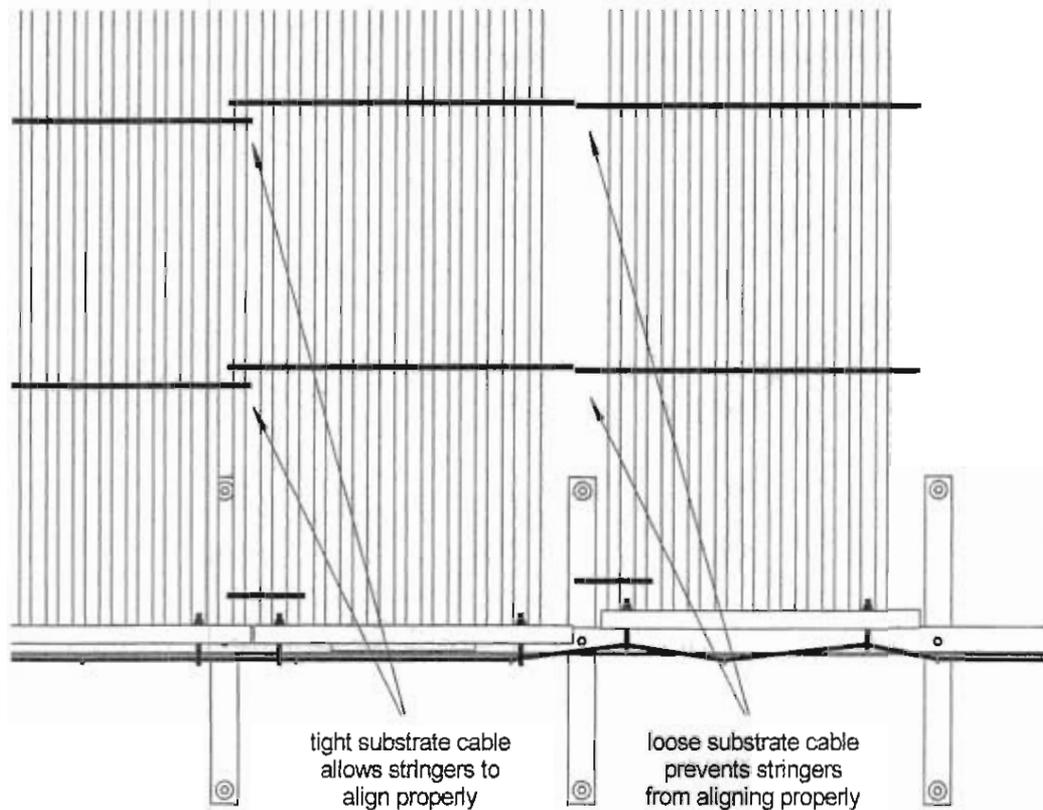
4. Slide the hose clamp back to the end stringer and tighten it to prevent the connecting picket from backing out (Figure 15).



**Figure 15.** *Hose clamp placement*

**Problems:** If the stringers don't overlap properly the problem may be on of the following:

1. Loose cable (Figure 16).
2. Angle flow (Figure 12).
3. Wrong stringer configuration caused by a faulty repair.
  - Replace and repair panel.



**Figure 16.** *Result of a loose substrate cable*

### *Installing the Other Components*

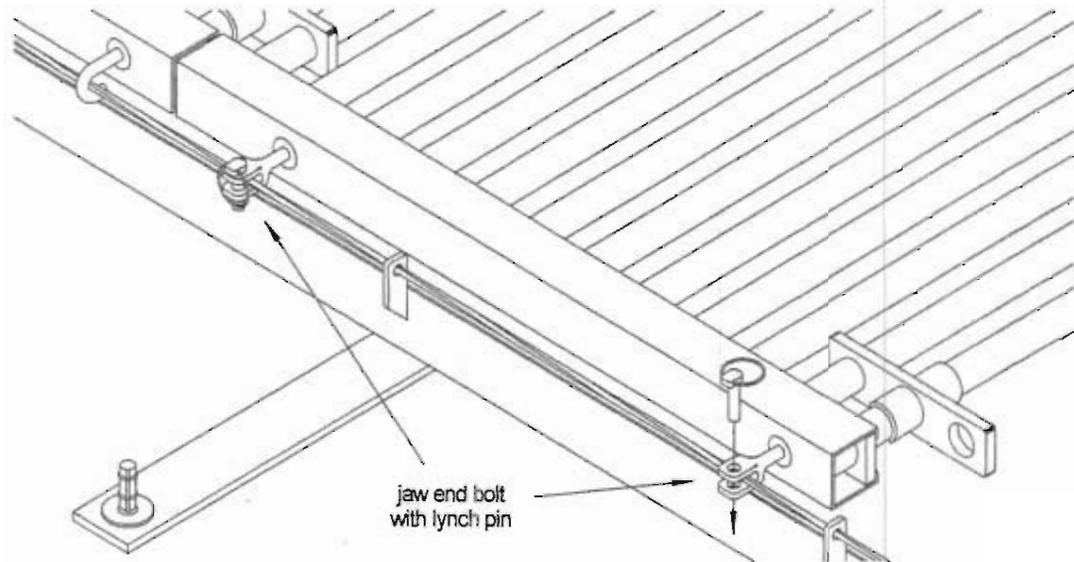
*The Passage Chute* is a modified panel with vertical walls and a gate to allow upstream passage of fish. It is installed just like a panel (Figure 1).

- Locate passage chutes in moderate depth and current, not directly in the thalweg where flood debris might damage them, or in slow water where fish might have trouble finding them.

*The Skiff Gate* is made up of three weir panels specially modified to minimize damage from boats passing over them (Figure 1). An angled plate of UHMW black plastic is fastened to the downstream end of the panel to deflect it beneath the hull of a passing boat. Base hooks are replaced by jaw end bolts with lynch pins (Figure 17) so the impact of a boat will not dislodge the panel from the rail.

- The resistance boards on skiff gate panels are left unset (flat), unless they submerge to such an extent fish might pass upstream over them. Even with several inches of water flowing over the skiff gate, fish will probably not find

their way over it. Crew must monitor and adjust the resistance boards if there is any indication fish are passing upstream over the skiff gate.



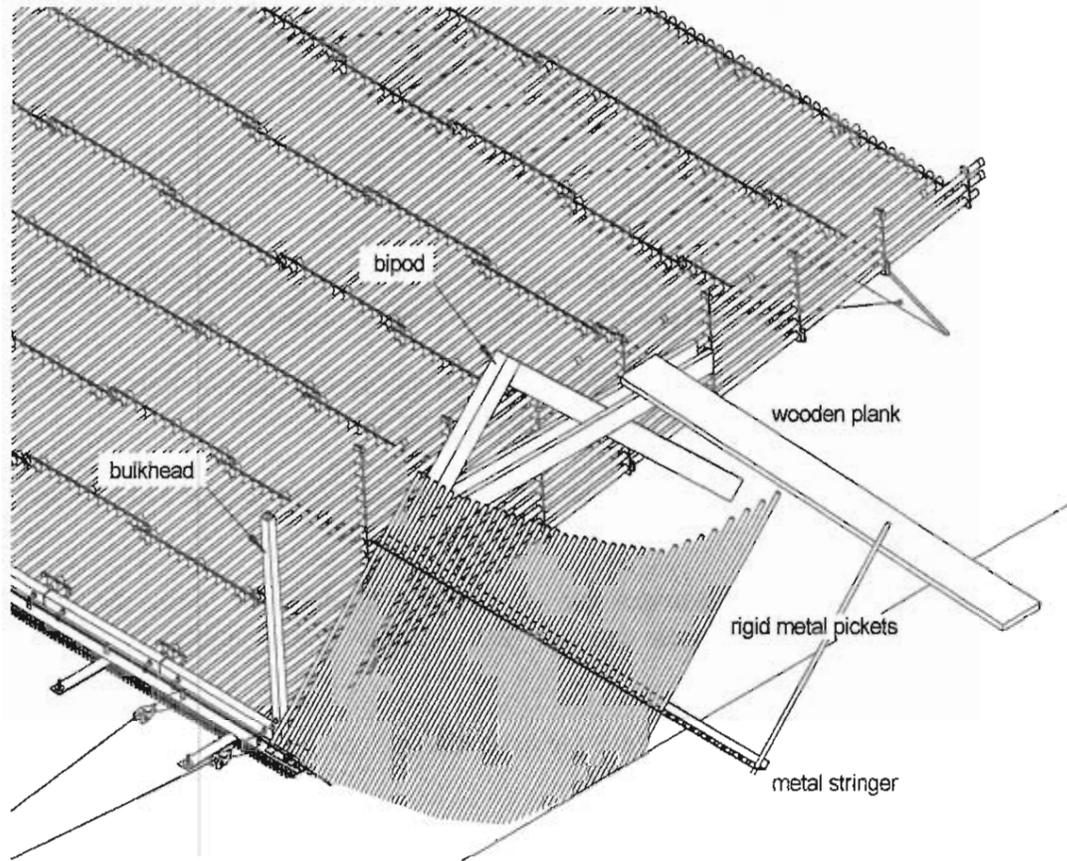
**Figure 17. Skiff gate attachment**

- Locate the skiff gate where the depth for boat passage will be adequate throughout the season, but not in the swiftest portion of the river.

**Bulkheads and Fixed Weir Materials** are installed at both ends of the weir. Bulkheads are attached with a connecting picket, just like a panel turned on its edge. A section of fixed weir is installed between the bulkhead and bank (Figure 18).

1. Install the bulkhead with a connecting picket.
  - Overlap the bulkhead stringers on the upstream side of the adjacent panel's stringers. This position will keep the bulkhead from sliding downstream in the current.
2. Stand the bulkhead vertically and install a bipod or tripod alongside.
  - Place sand bags on the pod to anchor it against the current.
3. Extend a fixed weir stringer between the bank and the pod.
4. Thread rigid metal pickets through the stringer holes and pound them into the substrate until the bank is "fish tight".
5. Tie the bulkhead to the fixed weir by lacing parachute cord or thin rope between the adjoining pickets.

6. Place sand bags to prevent undercutting along the bank or scouring around the fixed weir.



**Figure 18.** Bulkhead and fixed weir materials

**The Live Trap** is installed directly in front of a passage chute or pair of bulkheads. Cables with strainers lead from the front corners of the trap to duckbill anchors driven upstream (Figure 1).

1. Remove any rebar stakes from in front of the rail that would interfere with the trap.
2. Butt the rear of the trap against the front of the rail.
3. Attach the fish passageway.
  - If a passage chute is used with the trap, a plywood enclosure mounts to the back of the trap and fits neatly inside the chute opening.
  - If a pair of bulkheads is to be used with the trap, a single panel is removed and bulkheads placed on either side of the opening with their aluminum bases tied vertically to the rear of the trap.
4. Drive a pair of duckbill anchors to secure the trap in the event of a flood.

## WEIR REMOVAL

Removing the weir requires little technique that can't be gleaned from studying its installation. The following are tips that can help things go more smoothly.

### Removing the Connecting Pickets:

1. Remove any cobblestones lodged along the connecting picket. Cobblestones act like wedges that lock the connecting picket in place when pulled or twisted.
2. Loosen retaining hose clamp and remove the connecting picket. Remember to grab the hose clamp as the picket passes out of the last hole.
  - Twist the picket using large pliers if necessary, to loosen sand inside picket holes.
  - Ensure no cobblestones are on the face of the weir along the connecting picket. Cobblestones can act like wedges when pulling or twisting the connecting picket.
3. Once the picket is removed, place the hose clamp back over the end of the picket and tighten it for next season.

### Removing Panels:

1. Loosen the cable if the panels are locked into the gravel.
  - Gravel tends to pack tightly around the base of the panels over the course of a season. This jamming prevents the panel from being pushed forward to unhook it from the cable. Rather than clean the gravel from around the base of each panel, loosen the cable and pull a few feet of slack. Loosening the cable has little or no effect on the weir since the panels are essentially locked into the substrate.
  - With slack in the cable, pull the base of the panel straight up out of the gravel and release it from the cable.
2. Use a boat to push the panels from behind if the current is too strong to allow waders to push it forward (Figure 19).
3. Re-tension the cable if the rail is to be left in the river over winter. See instructions on pages 13 and 14, under *Substrate Rail Inspection*. This step makes installation much easier the following season, especially in high water.

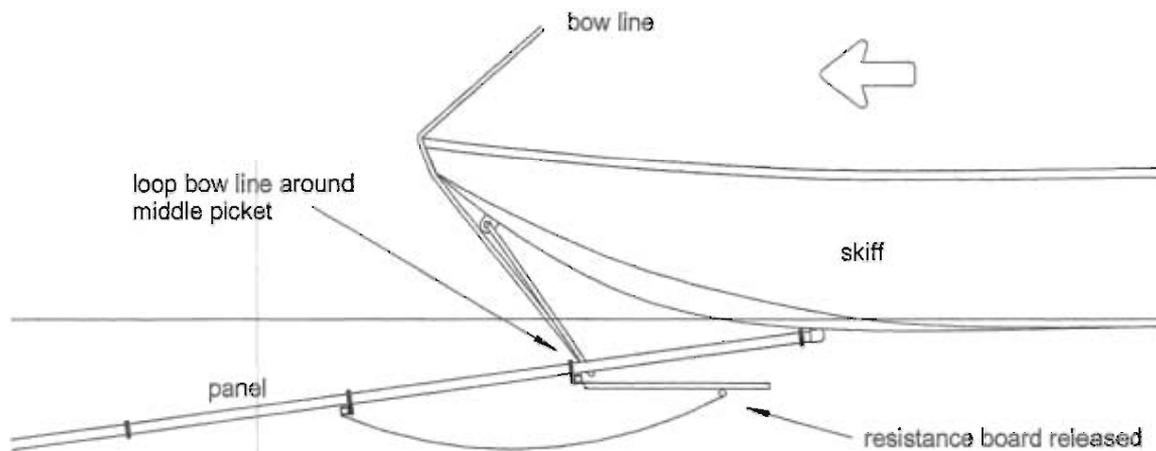


Figure 19. *Pushing a panel with a skiff*

### Removing the Rail:

1. Remove the 3/8" substrate cable from the rail.
  - Once the substrate cable is removed, snorkelers can use the duckbill strainer cables to hold themselves in the current to remove rail sections.
2. Remove two 3/8" bolts from the same side of each rail splice.
3. Remove the rebar stakes using locking pliers to twist and pull them from the gravel.
4. Remove the rail sections.
5. Remove the substrate apron taking care not to bend the rebar.
6. Remove the strainers and cables from the duckbill anchors. Flag each duckbill eye with brightly colored surveyor tape to more easily find it next season.
  - Strainer cables may be left on the duckbill anchors to make the anchors easier to find the following season.
7. Duckbill anchors are designed to remain in the substrate. However, they can be removed from some substrates by pulling them vertically with a jack. Their removal might only be necessary if the weir is to be moved to another location.

## Winter Storage:

1. Select a storage site on high ground, a safe and reasonable distance from the bank.
  - Leave an adequate buffer of vegetation between the river and the storage site to prevent erosion along the bank
  - Use a single access path to reduce erosion along the bank.
2. Stack panels up to 15 high and secure them from floodwater.
  - Stack panels with the resistance board side facing up. When stacking, alternate the #1 panels (plain end caps) with the #2 panels (red end caps). Alternate panel orientation too, with white end caps at one end of the stack and red end caps at the other. This method makes the stack shorter and more stable.
  - Ensure the bottom panel in a stack is level and free of obstructions beneath that might cause damage as more panels are added to the stack. Use timbers beneath a stack if the ground is irregular with stumps or humps.
  - Secure the panels from floodwaters by anchoring each stack with rope or cable to a nearby tree. Thread the rope or cable through each panel in the stack. If trees are not available, use duckbill anchors.
3. Store all metal components on timbers or pallets so they are not lost in vegetation or buried by flood deposition.
  - These include rail assemblies, rebar stakes, cable, and fixed weir materials.
4. Store the substrate apron material flat or folded in 10' sections to avoid irregular kinks.
  - Drive several metal pickets into the ground through the apron mesh, to secure the apron from floodwater.
5. Hardware and other loose items should be placed in durable containers and labeled.
  - These items include rail bolts, duckbill anchors, cable strainers, cable clips, rock drill bits, hose clamps, sand bags, and etcetera.
  - Store these items in a secure place with your tools and camp supplies to prevent loss or theft.
  - Cardboard boxes should not be used to store these items. Coffee cans, sand bags, and plastic bins or totes are good containers for this purpose.