Telescopic Weir for Fisheries Applications

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ABSTRACT

Enzenhofer, H.J., and Cronkite, G.M.W. 2010. Telescopic weir for fisheries applications. Can. Tech. Rep. Fish. Aquat. Sci. 2864: iii + 12 p.

We describe and illustrate the design, construction and installation of a telescopic weir that can be used to divert migrating fish to areas where they can be observed. The sectional telescopic design means that this weir can be deployed from a fully retracted length of 3m to a fully extended length of 10 m. The entire weir can be transported as a single load in a pick-up truck and can be installed by two people wading or by two people in a boat, in 4 hours. After the duration of deployment the removed weir leaves minimal disturbance, which is an important feature in environmentally sensitive areas. All components of the weir are constructed of durable aluminium, stainless steel and galvanized materials and are interchangeable between sections. This weir is used seasonally by the Pacific Salmon Commission on the Fraser River at the Mission hydroacoustic facility and with the addition of small mesh panels was used to monitor downstream migrating juvenile sockeye salmon (*Oncorhynchus nerka*) smolts on Sweltzer Creek that outflows Cultus Lake, BC. The estimated construction costs were $6000 CAN in 2009.

RESUME

Enzenhofer, H.J., and Cronkite, G.M.W. 2010. Telescopic weir for fisheries applications. Can. Tech. Rep. Fish. Aquat. Sci. 2864: iii + 12 p.

Description et illustration du concept, de la construction et de l'installation d'un barrage à poissons télescopique destiné à diriger les poissons en phase d'avalaison dans des sites où ils peuvent être observés. La fonction télescopique confère à l'installation une plage de déploiement comprise entre 3 mètres (position rétractée) et 10 mètres (déploiement maximal). L'appareil se transporte d'un seul tenant dans une camionnette et peut être installé en moins de 4 heures par deux personnes travaillant les pieds dans l'eau ou à bord d'une embarcation. Ce type d'installation permet de minimiser les perturbations subies par le site après son retrait, avantage non négligeable pour les zones écologiquement sensibles. Les divers éléments du barrage sont construits en aluminium, en acier inoxydable et en acier galvanisé et sont interchangeables d'une section à l'autre. Ce barrage à poissons est utilisé saisonnièrement par la Commission du saumon du Pacifique, à la station hydroacoustique de Mission. Le dispositif a été équipé de panneaux faits de grillage à mailles fines pour pouvoir observer les smolts de saumons rouges (*Oncorhynchus nerka*) en avalaison dans un émissaire du lac Cultus, le cours d'eau Sweltzer Creek (Colombie-Britannique). Coûts de construction (2009) : 6000 $ CAN.

INTRODUCTION

Fish weirs or traps have been in existence for thousands of years and were intended to move fish into an area where they could be caught. A more recent use of weirs is to guide migrating fish to specific areas or restrict areas where their migration occurs when performing visual and acoustic assessment of fish populations in rivers (Cronkite et al. 2006; Holmes et al. 2006). Many styles of weirs exist with the design, construction and complexity dependent upon the stream or river condition in which they are deployed, and the particular goal for their use (Anderson and McDonald 1978; Enzenhofer et al. 2005). Weirs used in large fast flowing rivers will require a more complex and heavier design than a weir deployed in a smaller water body. An important consideration in the weir design is whether it will be a permanent structure or must be removed after its use without disturbing the site.

We have designed a telescopic weir that can be installed by two people wading in the water or from a boat. The weir will conform to varying degrees of bank slopes, river bottom profiles and substrate types. Once removed, the weir leaves no trace of disturbance, which is an important consideration when working in streams or waterways. The complete weir can be transported by pick-up truck or by boat, and can be installed in water up to 2 m deep and in current velocities as high as 1.6 m/s. Because the weir is telescopic it can be deployed between its retracted length of 3 m to a fully extended length of 10 m. The design allows multiple weirs to be joined if an application requires more than 10 m of length. Weir components are simple in design and are interchangeable between each telescopic section.

This report describes the design, construction and deployment of the telescopic weir. The weir is anchored to the river substrate by stainless steel (SS) pins and is supported against current flow by diagonal braces connected to the top of the weir and anchored on the downstream side with SS pins. Vertical conduit pipes are placed every 5 cm, leaving a 2.7 cm opening between adjacent pipes. The pipes can be easily removed to allow cleaning of debris which may accumulate during operation. We provide assembly instructions for installation either by wading or from a boat, and outline some modifications to the weir for specific user needs. We include costs in Canadian dollars (2009) for the complete weir components.

DESCRIPTION

The telescopic weir consists of three-main components: 1) a three-section aluminium main frame, supported by stainless steel (SS) anchor pins, that can span a river cross-section from 3 m when retracted up to 10 m when fully extended; 2) a diagonal brace system that supports the weir main frame against the current flow; and 3) vertical conduit pipes inserted into the main frame that conform to irregular bottom profiles (Fig. 1).

The main frame has a central section (4.3 m length) that cradles two shorter sections (3m lengths) that retract into or extend from the central section. Polyethylene lined aluminium brackets, welded to both ends of the middle section form a sliding mechanism that ensures non-binding operation (Fig. 2). The shorter main frame sections can be completely removed from the sliding mechanism if desired.

Eight extendable diagonal braces connect to the weir main frame by means of diagonal brace holders (Fig. 3). There are three styles of diagonal brace holders: 1) one shore diagonal brace holder that couples an anchor pin to the weir main frame, allowing setting of deployment height and the connection of two diagonal braces for support (Fig. 3a); 2) three section end diagonal brace holders that attach the ends of the weir main frame to anchor pins by downstream diagonal braces (Fig. 3b); and 3) three intermediate diagonal brace holders that slide onto the weir main frame for attaching a diagonal brace and anchor pin anywhere along the weir (Fig. 3c).

CONSTRUCTION

Main frame

The telescopic weir main frame consists of three pieces of rectangular aluminium tubing (7.62 cm x 10.16 cm x 6 mm thickness) cut into two lengths of 3 m and one length of 4.3 m. At each end of the main frame section a receiver pipe (3.2 cm outside diameter (OD) x 8.0 cm) is welded to accept a 19 mm thickness SS pin (Fig. 2). The middle main frame section (4.3 m length) has an aluminium plate welded on each end (15.0 cm x 20.0 cm x 6mm thickness) that has been cut out to accept the shorter 3 m sections of the main frame (Fig. 2). Polyethylene plastic (15 cm x 20 cm x 14 mm thickness) is bolted to the aluminium plate on each end of the largest section (4.3 m) and cut out at the same dimensions as the aluminium plate (Fig. 2). A similar cut-out aluminium plate is welded 25 cm back from the aluminium end plates on the 4.3 m main frame, and lined with the same polyethylene material to provide a cradle for the shorter main frame sections. Each main frame section contains holes (25 mm x 5 cm spacing) to accept the vertical conduit piping (Figs. 1 and 2).

Diagonal Braces

Each extendable diagonal brace consists of an aluminium pipe (3.81 cm OD x 2.0 m) centrally welded to a bolting bracket (an aluminium plate, 4.0 cm x 4.0 cm x 6 mm thickness) with two half round plates (4.0 cm x 5.0 cm x 6 mm thickness) welded to each end and drilled for a 13 mm bolt. The bottom end is drilled for a 10 mm lock pin and a second pipe (2.54 cm OD x 1.5 m) is inserted to enable telescopic extension of the diagonal brace. A pivot anchor pin holder is welded at a 45° angle to the bottom of the extension pipe that has 10 mm holes at 15.0 cm spacing drilled along its length for locking pin insertion. The pivot anchor pin holder has two rounded aluminium plates (6.5 cm x 8.0 cm x 6 mm thickness) welded to a flat bar (2.54 cm x 6.5 cm x 6 mm thickness) and drilled for a 13 mm bolt. The pivoting anchor pin holder bolts to a plate (6.6 cm x 15.0 cm x 6 mm thickness) welded to an aluminium pipe (25 mm OD x 15.0 cm) that accepts the SS anchor pin (Fig. 3).

Diagonal brace holders (three styles)

The shore diagonal brace holder consists of square aluminium tubing (10 cm x 10 cm x 12.5 cm x 6 mm thickness) with a pipe welded to each side (2.54 cm x 4.0 cm) for bolting on a diagonal brace (Fig. 3a). One end of the tubing is drilled (25 mm diameter) to accept a drop pin (25 mm x 15.0 cm) and the other end drilled for a SS anchor pin. An anchor pin receiver, consisting of a 2.54 cm pipe with a threaded block for an 8 mm T-bolt, is welded to the top of the brace holder.

Each section end diagonal brace holder consists of an aluminium flat bar (7.7 cm x 27.8 cm x 6 mm thickness) rounded at each end and bent at right angles creating a C-shaped holder. A pipe (2.54 cm OD x 4.0 cm) welded to the long side is used to bolt a diagonal brace (Fig. 3b). An anchor pin receiver is welded to the top and a 25 mm hole is drilled for accepting an anchor pin.

Intermediate diagonal brace holders consist of an aluminium flat bar (7.7 cm x 27.8 cm x 6 mm thickness) rounded at each end and bent at right angles creating a C-shaped holder that slips over the 10.16 cm deep weir main frame (Fig. 3c). The ends are drilled with 30 mm diameter holes and a pipe (2.54 cm x 4.0 cm) is welded to the long side for attaching to a diagonal brace.

ASSEMBLY

Assembly of the telescopic weir begins with establishing the weir deployment height. The selected height should allow the main frame to be level with, and above the water surface once fully installed. The design of the telescopic weir is such that the main frame and diagonal bracing are installed and the height adjustment locked in place to the SS anchor pins before the individual

vertical conduit pipes are inserted. The weir can be installed by two people wading into the water where the depth and the current velocity permit safe working conditions. When wading is not possible the weir can be assembled from a boat. In either instance, the shore end anchor pin is first driven into the substrate and attached to the weir's main frame as it lies parallel to the shoreline by pivoting the shore diagonal brace holder (Fig. 3). Assembly of the telescopic weir occurs in the following order:

Wading method:

1. Carry the fully retracted weir out to its deployment position while pivoting on the shore end anchor pin. The T-bolt, which holds the weir main frame to the anchor pin, should be snug but not fully tightened.
2. Place a section end diagonal brace holder (Fig. 3b) on the receiver pipe at the end of the first weir section (Fig. 2), insert an anchor pin and drive it into the substrate.
3. Level the weir main frame above the water surface and tighten both of the first weir section T-bolts.
4. Bolt the extendable diagonal braces to the upstream and downstream side of the shore diagonal brace holder (Fig. 3). Select an appropriate length for the diagonal brace by removing the lock pin and adjusting the extension pipe to the required length. Insert the anchor pin into the pivot anchor pin holders and drive the pin into the substrate.
5. Bolt a diagonal brace to the end of the first weir section's diagonal brace holder (Fig. 3). Once installed the diagonal brace can be pivoted above the water surface and the appropriate length for the extendable brace set. Add an anchor pin to the pivot anchor pin holder and hold the pin along the diagonal brace while lowering to make contact with the substrate. Pivot the anchor pin to the vertical position and drive the pin into the substrate.
6. Extend the second and third weir sections together as one piece. Install the section end brace holder (Fig 3b) on the end of the second section and insert the steel anchor pin. Drive the anchor pin into the substrate, level the weir with the water surface and tighten the T-bolt.
7. Bolt a diagonal brace to the end of the second weir section. Adjust the length of the diagonal brace, add the anchor pin and drive the pin into the substrate as in Step 5 above.
8. Extend the third weir section and install the section end diagonal brace holder. Insert the anchor pin, set the weir height and secure the T-bolt. Install the end diagonal brace and anchor pin as in Step 5 above.
9. At the midpoint of each main frame section install an intermediate diagonal brace holder (Fig. 3c) with an anchor pin. To each holder install a diagonal brace and secure with an anchor pin.
10. Insert all the vertical conduit pipes to complete the weir installation.

Boat method: (requires two people in the boat at all times)

1. Slowly transport the retracted weir upstream to its deployment position while pivoting on the shore end anchor pin (as above). Hold the boat in position under power (bow pointing upstream) allowing free access to the end of the first weir section.
2. Install the section end diagonal brace holder and anchor pin and level the weir to the water surface (same as for the wading method).
3. Install the diagonal brace to the section end diagonal brace holder. Insert the anchor pin, rotate to the vertical position and drive the anchor pin into substrate. This can be accomplished by tying the boat's bow to the weir main frame and holding the boat in position, downstream of the weir with the starboard side inshore of the diagonal brace.
4. From the port side of the boat install the intermediate diagonal brace holder with an anchor pin and install a diagonal brace. Insert an anchor pin, lower it to the substrate and drive into the substrate with pin in the vertical position.
5. Assemble the extendable diagonal braces to the shore diagonal brace holder and fully install the anchor pins as in Step 4 for the wading method.
6. Extend the second weir section with the bow of the boat tied to the anchor pin at the end of the first weir section.
7. Assemble the remainder of the weir components by positioning the boat with the bow strategically placed along the weir main frame. This provides work space from both the port and starboard sides.

COSTS

The approximate costs for the complete telescopic weir are shown in Table 1. All figures are in 2009 Canadian dollars and are based on all vertical components being 3.0 m in length (SS anchor pins and 19 mm E.M.T. galvanized conduit pipe). Some savings could be achieved if the weir was to be deployed in a shallow stream and full lengths were not required. We do not present the cost savings from using shorter lengths as we felt that short lengths limit the general use of the weir in a variety of streams.

Table 1. Approximate cost for a telescopic weir

Item	Description	Cost
Telescopic weir	Three-piece main frame (3 m, 4.3 m, 3 m lengths) -telescopes to cover overall length of 10 m -fully retracted length 4.43 m -hole punched (25 mm x 5 cm spacing) Includes (1) - shore diagonal brace holder with drop pin (3) - section end diagonal brace holders (3) - intermediate diagonal brace holders (8) - extendable diagonal braces	$3200
Anchor pins	(15) – stainless steel (19 mm x 3 m length)	$1100
Conduit pipe	(200) – galvanized (19 mm x 3 m length) commonly known as ¾" E.M.T	$1700

DISCUSSION AND CONCLUSION

The telescopic weir is an effective tool for diverting migrating fish to preferred areas for acoustic or other assessment, particularly when large scale permanent structures are not warranted and when weir deployment is for limited duration and removal is required without impacting the surrounding environment. The weir is portable by design, as the largest main frame component can be easily carried by two people. The entire weir can be carried in a single pick-up truck load, reducing transportation costs. Typically two people can install the fully extended 10 m length of weir in 4 hours. The weir will conform to irregular bottom profiles and can be installed on various substrates because the conduit pipes are added after the main frame and diagonal brace system are fully installed. If the substrate is comprised of solid bedrock then the anchor pins cannot be driven in and an alternate method of securing the pins would be required. This could be done by applying sandbags to hold the pins in place in slow currents or by drilling holes in the bedrock to create pin holders in faster currents. Debris can be cleaned from the telescopic weir by sliding up the appropriate pipes and allowing the debris to pass through downstream.

The telescopic weir is capable of operating in water up to 2 m deep and in current velocities up to 1.6 m/s. The weir was originally designed for the Pacific Salmon Commission hydroacoustic facility on the Fraser River at Mission, BC. This boat access site is affected by tide fluctuations of up to 1.5 m and the substrate consists of soft sand, necessitating assembly and deployment of the weir from a boat (Fig. 4).

The telescopic weir design can be modified to accommodate studies which require a weir on both river banks. For example, we modified the telescopic weir to create a downstream-V opening on Sweltzer Creek

downstream of Cultus Lake, BC. This created a 3.5 m opening in mid-channel of the 13.5 m wide creek, in order to test the feasibility of counting sockeye salmon smolts with an imaging sonar system. In this application the third section of the telescopic weir was deployed as a stand-alone unit on the opposite bank, and small mesh panels were installed on the upstream side of the telescopic weir to prevent smolts from passing between the conduit pipes (Fig. 5).

The telescopic weir is useful for monitoring fish passage as it has a wide range of applications, is relatively inexpensive to build, is reusable, and is easily transported.

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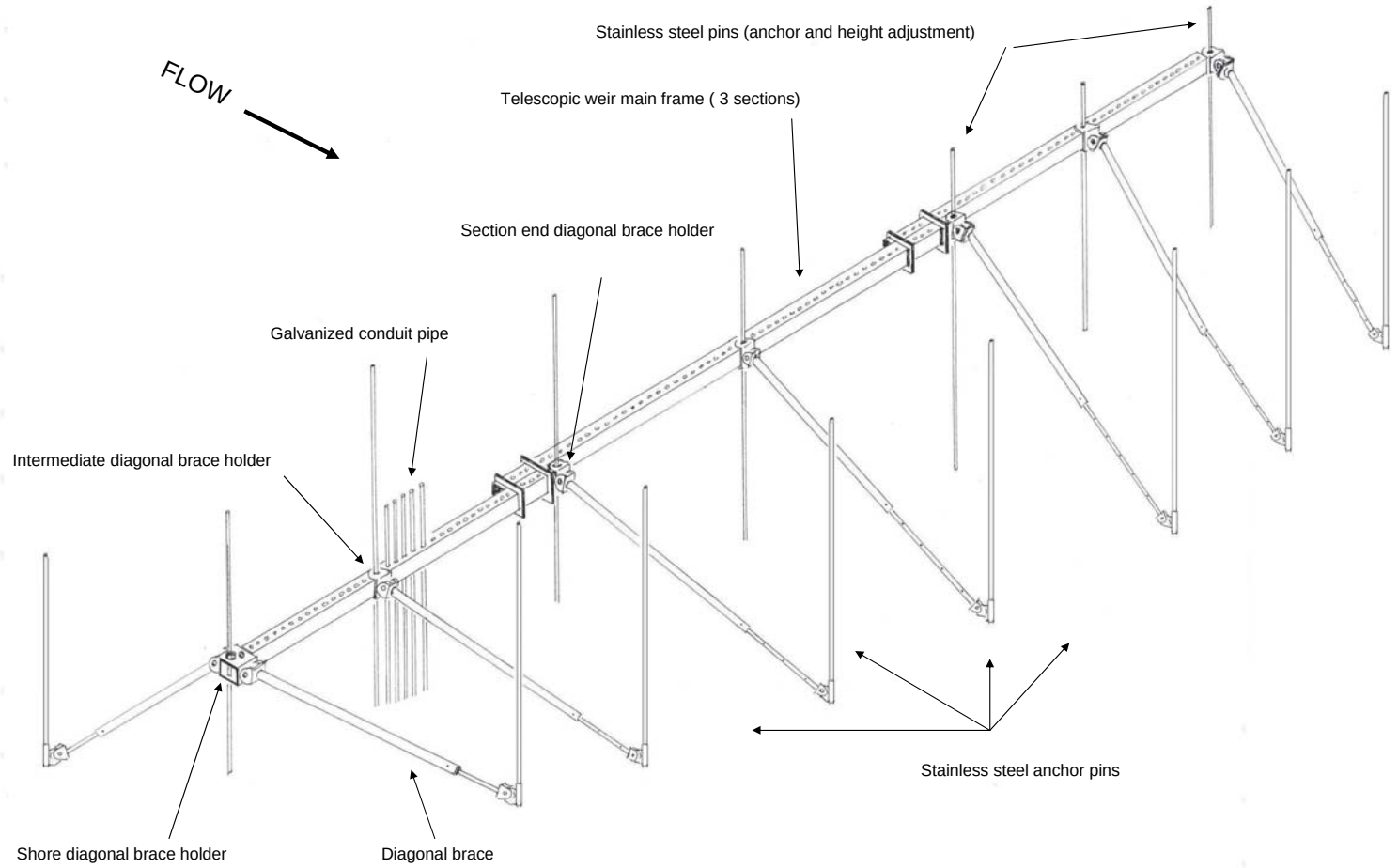

Fig. 1. Three-dimensional view of the telescopic weir showing all three sections deployed.

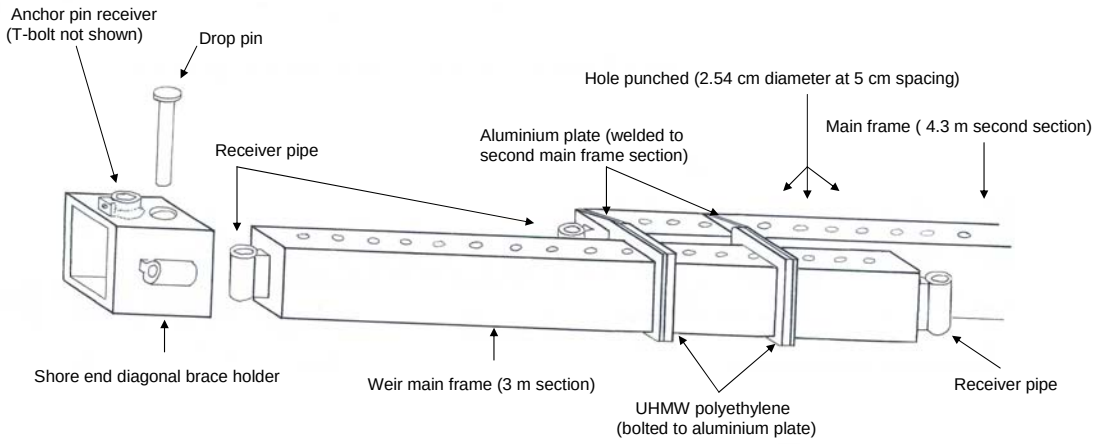

Fig. 2. Three-dimensional illustration of the telescopic weir showing the first weir section that slides along two aluminium plates welded to the longer main frame second section. Polyethylene added to these plates reduces friction and eases the retraction and extension of the weir main frames. Note that the figure shows one end only and the opposite end would be identical but reversed. The shore end diagonal brace shown would attach to the weir main frame by inserting the drop pin through the brace holder and receiver pipe.

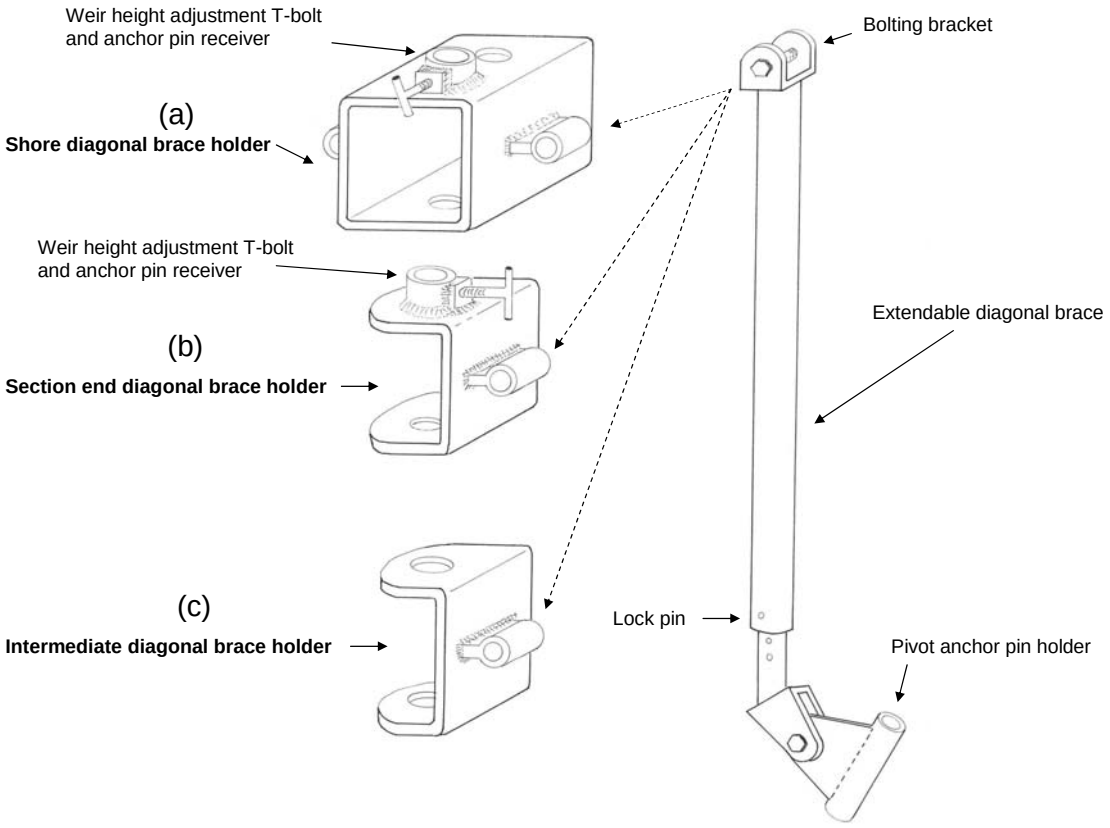

Fig. 3. Three-dimensional view showing the diagonal brace holders and an extendable diagonal brace that support a telescopic weir. (a) Shore diagonal brace holder for setting weir height and connects two diagonal braces. (b) Section end diagonal brace holder for setting weir height and connects to a diagonal brace. (c) Intermediate diagonal brace holder for attaching a diagonal brace and anchor pin anywhere along the weir.

Fig. 4. The telescopic weir deployed by the Pacific Salmon Commission at their hydroacoustic site at Mission, BC, on the Fraser River. This site is tidally influenced and the substrate is soft sand, requiring installation of the weir from a boat (top left) during a slack tide. Note that the boat is on the upstream side of the weir as current flow is minimal during slack tides. In most cases the boat would be positioned on the downstream side to install weir components. The picture on the right shows the fully installed 10 m telescopic weir. Photos taken by Andrew Gray (PSC, Vancouver, BC) on August 10, 2007.

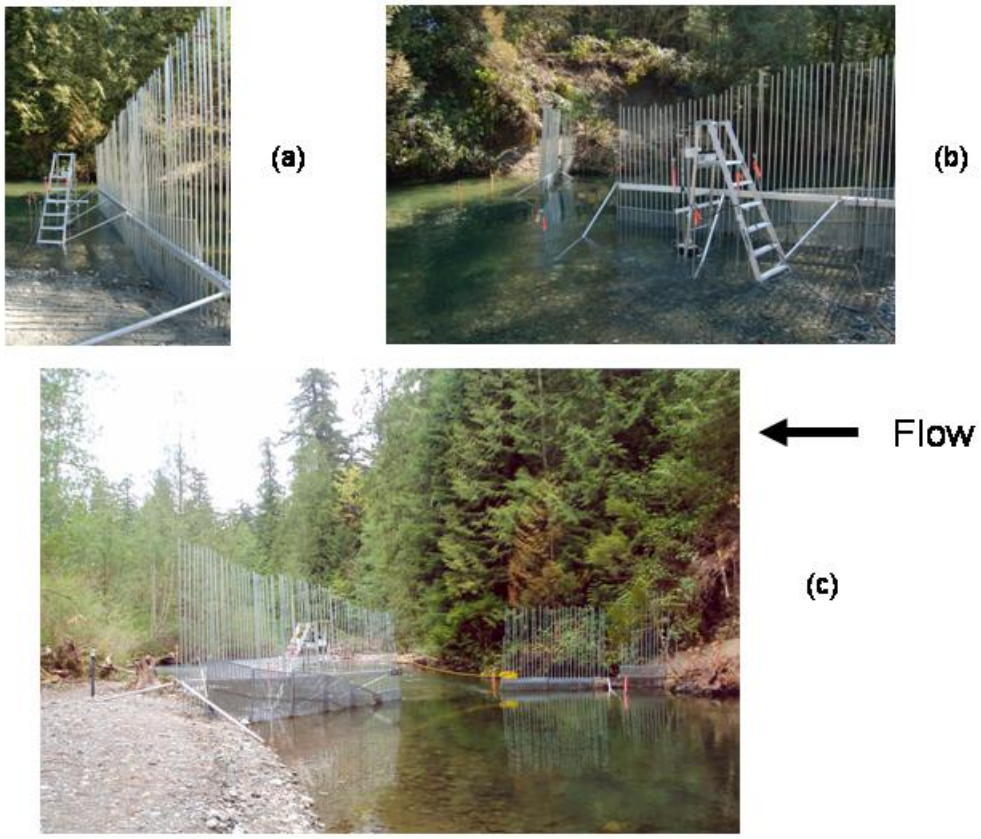

Fig. 5. The telescopic weir deployed on Sweltzer Creek at Cultus Lake, BC modified to create a 3.5 m mid-channel opening in order to count downstream migrating sockeye salmon smolts with an imaging sonar system. (a) First two sections of the weir deployed on a slight downstream angle. (b) Third weir section deployed on the opposite bank to create a downstream-V opening. (c) View from upstream of the weir showing the small mesh panels used to force fish downstream through the opening in order to be detected by the imaging sonar mounted to the stepladder. Photos taken by Sandra Enzenhofer on April 25, 2009.