A Sectional Fish Deflection Weir and Installation Boom for Riverine Applications

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A SECTIONAL FISH DEFLECTION WEIR AND INSTALLATION BOOM FOR RIVERINE APPLICATIONS

by

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ABSTRACT

Enzenhofer, H.J., Cronkite, G. and Holmes, J.A. 2005. A sectional fish deflection weir and installation boom for riverine applications. Can. Tech. Rep. Fish. Aquat. Sci. 2605: iv + 14 p.

We describe and illustrate the design, construction and installation of a sectional fish deflection weir that is an effective tool for guiding migrating Pacific salmon (*Oncorhynchus* spp.) through an area where they can be counted visually or with acoustic systems. The design goals for this weir included adaptability to different site configurations, adjustability for different cross-sectional profiles, accessibility for operating staff along its entire length, portability for installation and removal by two people, and flexibility in component construction. We also describe and illustrate an extendable boom and winch system that is used to install and remove weir sections. All components of the weir are constructed with galvanized or stainless steel materials and each weir section is 3.7 m long x 0.76 m wide. The weir has been used to facilitate the simultaneous collection of visual and acoustic counts of migrating adult Pacific salmon in the Thompson River and is currently used by the Pacific Salmon Commission on the left bank of the Fraser River at the Mission hydroacoustic facility and by the Ontario Ministry of Natural Resources at an experimental acoustic site on the Michipicoten River, near Wawa, Ontario. The estimated construction costs (CAN – 2005) are $700 for the installation boom and winch, $3,140 for the first weir section and $12,880 for five complete sections (18.5 m), making this weir an efficient and cost-effective alternative to bulkier permanent installations.

RÉSUMÉ

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Nous décrivons et illustrons dans cet article la conception, la construction et l'installation d'une fascine à poisson en sections qui peut être efficacement utilisée pour guider les saumons du Pacifique (*Oncorhynchus* spp.) en migration vers un secteur où ils peuvent ensuite être comptés visuellement ou à l'aide d'un système acoustique. L'objectif était de concevoir une fascine pouvant être adaptée à différents sites et à différentes sections de cours d'eau, accessible aux personnels d'exploitation sur toute sa longueur, portable, susceptible d'être installée et démontée par deux personnes, et flexible pour ce qui est de la construction des composants. Nous décrivons et illustrons également un système comportant une flèche extensible et un treuil permettant d'installer et d'enlever chaque section de la fascine. Tous les composants de la fascine sont en acier galvanisé ou en acier inoxydable et chaque section fait 3,7 m de long et 0,76 m de large. La fascine a été utilisée pour faciliter la collecte des données visuelles et acoustiques pour le dénombrement des saumons du Pacifique en migration dans la rivière Thompson et est actuellement utilisée par la Commission du saumon du Pacifique sur la rive gauche du Fraser à l'installation hydroacoustique de Mission et par le ministère des Ressources naturelles de l'Ontario, sur un site expérimental de mesure acoustique sur la rivière Michipicoten, près de Wawa (Ontario). On estime que les coûts de construction en dollars canadiens (2005) s'élèveront à 700 $ pour l'installation de la flèche et du treuil, à 3 140 $ pour la première section de la fascine et à 12 880 $ pour les cinq sections complètes (18,5 m), ce qui fait de cet équipement une solution de rechange économique face aux installations permanentes plus massives.

INTRODUCTION

Visual and acoustic assessments of fish populations in rivers to obtain estimates of abundance and species composition often require the use of weirs that restrict the area where fish passage occurs. For example, a partial weir can divert fish travelling near the bank through an area further offshore where the probability of detection is high and tracking is effective when using a fixed-location hydroacoustic system (Daum and Osborne 1998, Enzenhofer and Cronkite 2000). Weirs can also span the wetted width of a water body to direct fish passage through a designated opening for counting (Holmes et al. 2005). High water levels (discharge), fast current velocities, and fluctuating water levels can be a challenge to the installation, cleaning of debris or removal of a weir, particularly when personnel must use boats, wade or snorkel in the water to complete these tasks. We have designed a fish deflection weir that can be installed from the river bank without the need for staff to enter the water or use a boat. The weir design meets several operational goals including:

1. Adaptability - The weir is erected in 3.7 m sections that can be added or removed according to the width of the river and the vertical components of each weir section conform to varying degrees of bank slope or river bottom profiles.
2. Adjustability – The weir can be installed in waters up to 3.0 m deep and in current velocities as high as 2.5 $m \cdot s^{-1}$.
3. Accessibility – The weir provides access along its entire length with a walkway and handrails. These features allow regular cleaning of debris from the weir sections and enable personnel to perform operational duties without using boats or entering the water.
4. Portability – The weir can be installed or disassembled by two people. Weir sections are deployed by installing a boom and winch from the walkway at the end of the last installed section.
5. Flexibility - Weir components are pre-fabricated and interchangeable between sections and adjustments for water level are completed in-situ.

This report describes the design, construction and deployment of the sectional fish deflection weir used to partially or totally cover a river cross-section. Each weir section is anchored to the river bottom by stainless steel (SS) pins and the support stand legs supporting the walkway and the individual fence panels. A weir section has a fence panel frame that holds vertical conduit pipes placed every 5cm, leaving a 27 mm opening between pipes. We also include details of a boom and winch system which aids the installation or removal of weir sections and reduces the occupational risk to staff during installation or removal of the weir.

We include costs in Canadian dollars (2005) for the sectional weir components and the boom and winch system. The overall cost for a particular site will depend on the number of weir sections required.

The sectional fish deflection weir was originally designed by the Applied Technologies group of the Department of Fisheries and Oceans for experimental work at Spences Bridge on the Thompson River, a clear water tributary of the Fraser River (Enzenhofer et al. 1998). The Spences Bridge experiment compared counts of migrating Pacific salmon (*Oncorhynchus* spp.) obtained with a split-beam acoustic system to simultaneous visual counts recorded by a video camera as fish passed through a common sample area for the acoustic and video systems. Approximately 20 m of deflection weir was installed along one bank of the Thompson River to divert near shore migrating salmon offshore so that they would pass through the beam of the acoustic transducer placed immediately upstream of the weir. This weir design is currently used by the Pacific Salmon Commission on the Fraser River at Mission, BC, and by the Ontario Ministry of Natural Resources on the Michipicoten River in Wawa, Ontario.

DESCRIPTION

The sectional fish deflection weir consists of three components: 1) a support stand which is anchored to the river bottom, and provides a staging platform for the walkway, handrails and a fence panel frame; 2) a walkway which connects the weir sections together and provides structural strength; and 3) a fence panel frame that holds the individual vertical pipes used to block fish passage (Fig. 1).

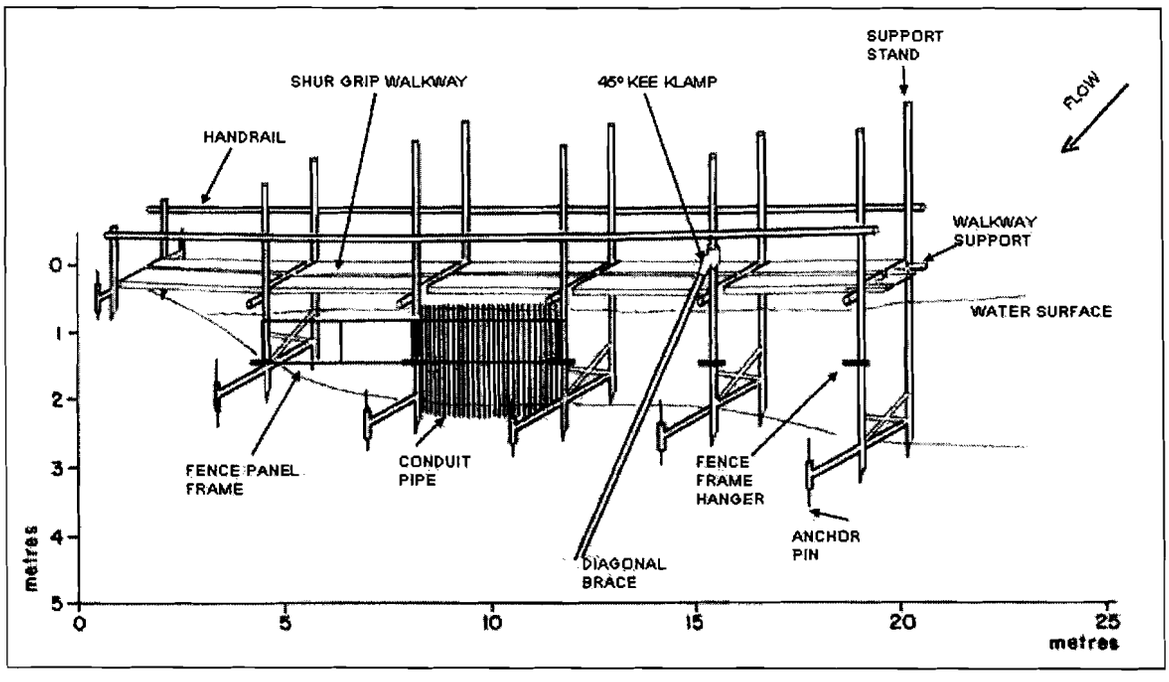

Fig. 1. Three-dimensional view of 5 sections of the fish deflection weir installed on the right bank of a river.

Galvanized or stainless steel (SS) pipe and fittings are used in the construction of all weir components. Pipe components are assembled using 3.81 cm KEE KLAMP ® slip-on pipe fittings having an axial load capacity of 907 kg per set screw. We use three types of KEE KLAMP fittings for the sectional weir: 1) a cross-over for joining two pipes at 90°; 2) a straight coupler for joining two pipes end-to-end; and 3) a single socket tee for joining two pipes at 45° (Fig. 2). The 45° KEE KLAMP is used for diagonal bracing on the downstream side of the weir (Fig. 1) to provide extra lateral support when current velocities are high.

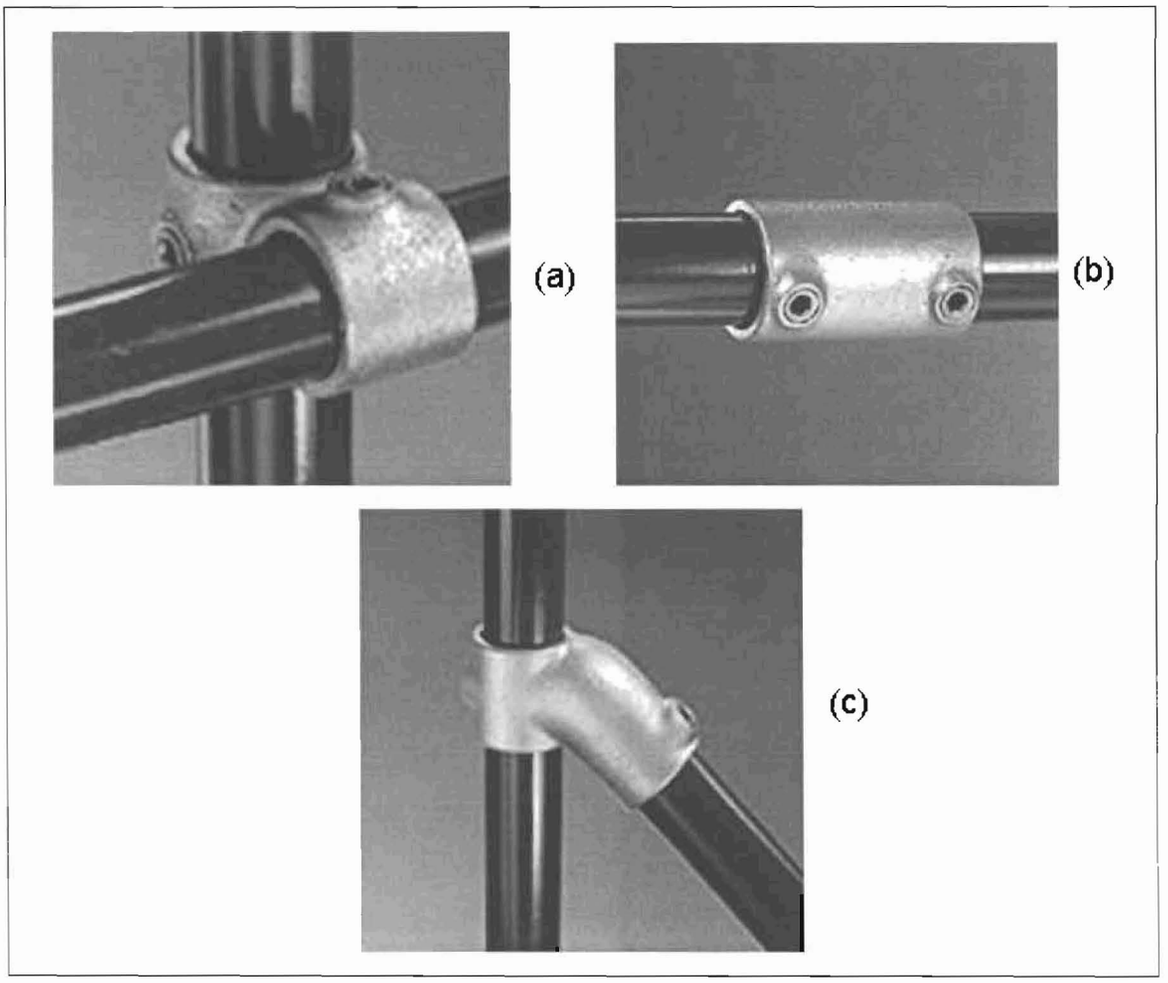

Fig. 2. Slip on Kee Klamp® pipe fittings used for the sectional fish deflection weir. (a) cross-over for joining two pipe sections continuous and at 90° (b) straight coupler used to connect two pipes end to end and; (c) single socket tee to connect two pipes at 45°.

WEIR SECTION

A weir section consists of two support stands spaced 3.7 m apart and connected with two lengths of walkway (SHUR GRIP galvanized steel grating) bolted to a walkway support. A walkway support is suspended at each end of the section between the support stands using 3.81 cm KEE KLAMP slip-on pipe fittings (Fig. 3). Continuous handrails on both sides of the walkway connect the support stands adding structural strength to the fish weir. Handrail pipes

(3.81 cm schedule-40 pipe thickness x 6.4 m length) are passed through a cross-over KEE KLAMP on each support stand and a straight coupler KEE KLAMP connects two handrail pipes to make them continuous. A fence panel frame (3.7 m length) is placed between two support stands resting in a pocket of the fence panel frame hanger. Each fence panel frame has 24 mm diameter holes placed on 5 cm spacing along its length. Conduit pipes (19 mm diameter) of sufficient length to cover the depth of the water column are placed along the fence panel frame leaving an opening of 27 mm between pipes.

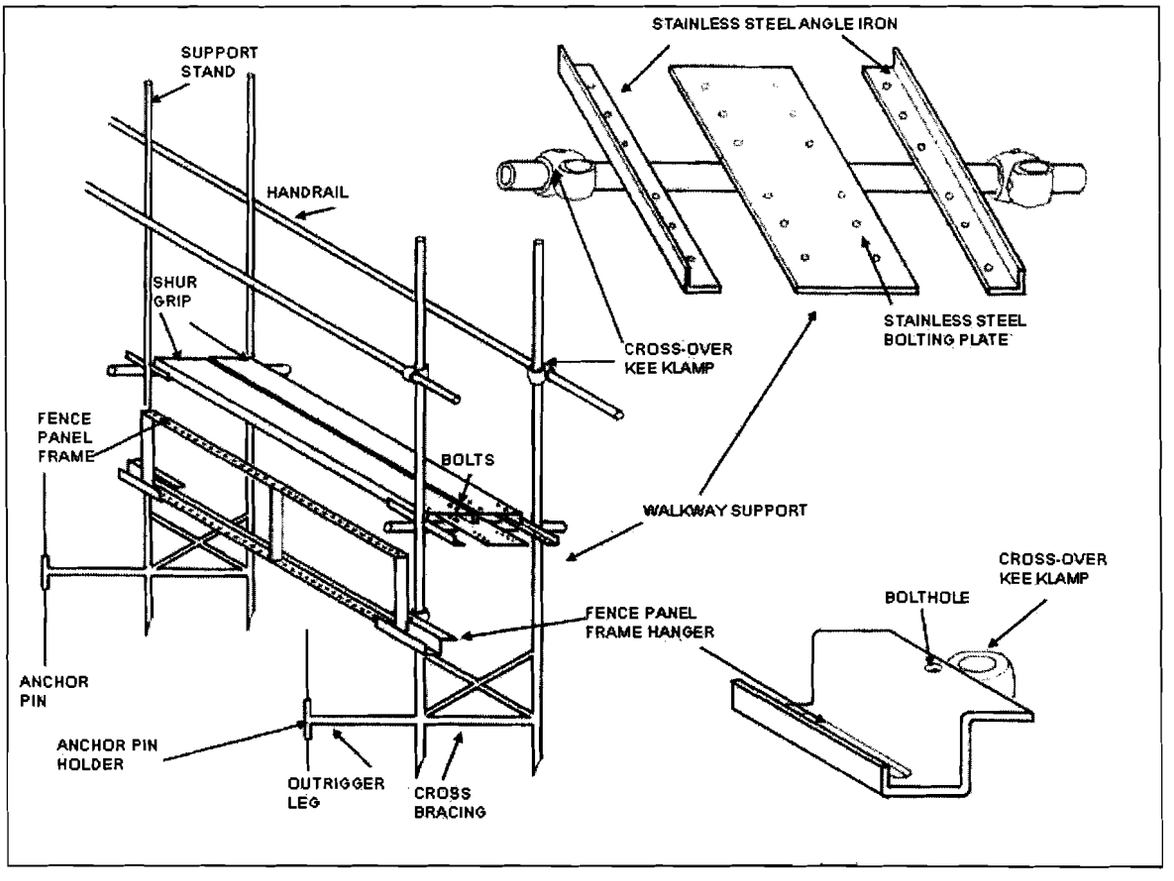

Fig. 3. Schematic of one 3.7 m length of sectional fish deflection weir. The enlarged view top right shows detail of the walkway support. The enlarged view bottom right shows fence panel frame hanger.

Construction

The vertical support stand consists of two galvanized pipes (3.81 cm schedule-40) 76 cm apart and welded together using 2.54 cm cross-bracing. An outrigger leg (3.5 cm x 1.6 m length) is welded at a right angle to the support stand and has a 20 cm piece of 2.54 cm diameter galvanized pipe that will hold a 16 mm diameter SS pin for anchoring to the river bed.

The walkway support is constructed of galvanized pipe (3.81 cm x 1.0 m) with a 10 gauge SS plate (15 cm x 46 cm) centered on and welded to the pipe.

Two 10 gauge SS angle pieces (3.8 cm x 5.1 cm x 46 cm) are welded on either side of the SS plate (62 cm apart) and centered along their lengths and are used to bolt two SHUR GRIP walkways side-by-side.

The fence panels are constructed of two aluminium angle pieces (7.6 cm x 5.1 cm x 3.7 m x 6 mm thickness) welded together using 6 mm plate (7.6 x 0.9 m) on either end and at the mid-point to create a frame. Holes (24 mm diameter) are machine pressed through the panel frame at 5 cm spacing. The fence panel frame hanger is 10 gauge SS plate (26 cm x 36 cm) machine bent to form a pocket (8.3 cm x 36 cm) in which the fence panel frame sits. The middle of the pocket is slotted (3.0 cm x 32 cm) to allow conduit pipe to pass through and a 13 mm hole is drilled for bolting a cross-over KEE KLAMP.

Assembly

Assembly of the sectional fish deflection weir begins with the placement of the first support stand anchored to the riverbank or bottom substrate. Anchoring can be as simple as using the 16 mm SS pins or with minor modifications, it could be bolted to threaded rod grouted into rock or cement retaining blocks (Not shown in this report as details are dependent on the site). Selecting the height of the walkway will depend on the bank type, bottom profile and water height. For example, if the weir is to cover a cut bank that is above the water surface, the walkway could be placed at ground level (Fig. 4a). If the weir starts on the shallow side of the river as in Fig. 4b, then the walkway height should be high enough to allow for fluctuations in the water depth.

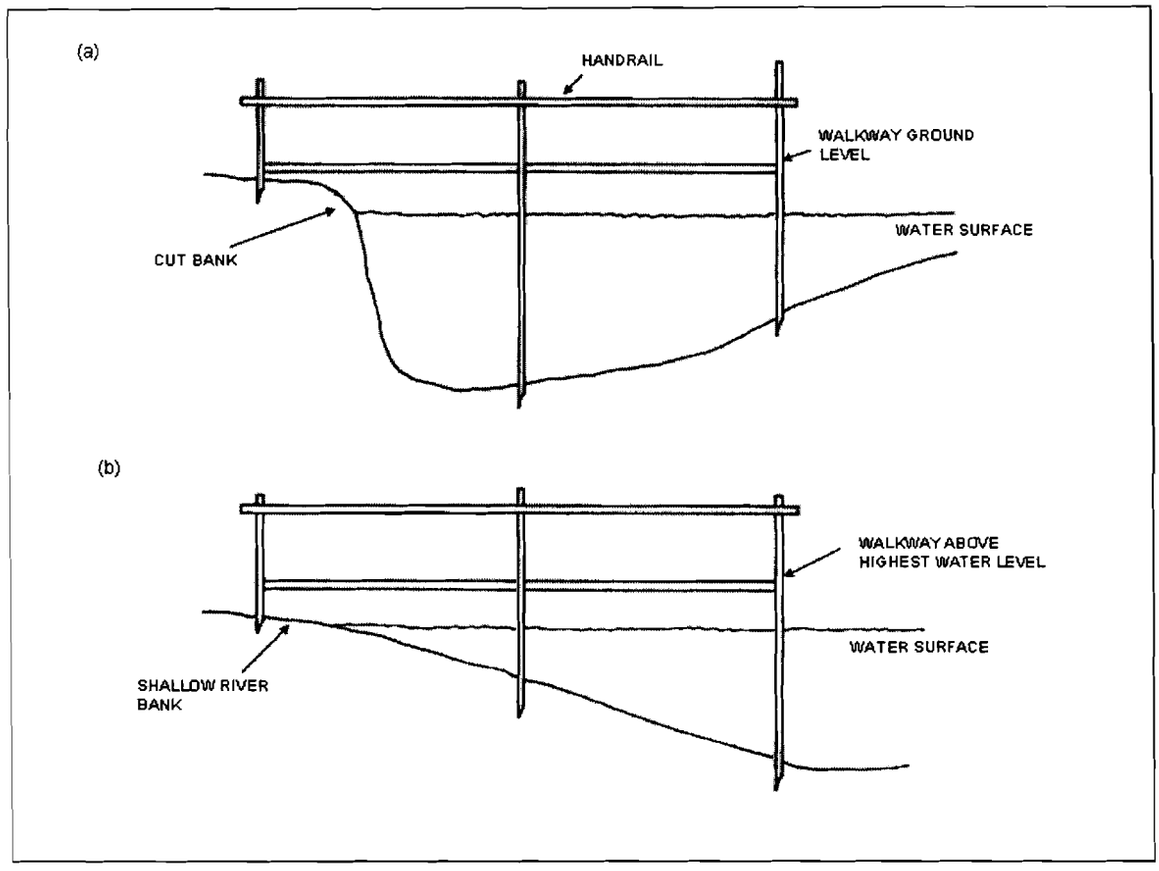

Fig. 4. Side view of two river bank profiles showing the placement of the sectional fish deflection weir. (a) Weir starts from a cut bank with the walkway height at ground level. (b) Weir starting from a shallow gradual sloped bank with the walkway height set to compensate for fluctuation in the water level.

Once the first support stand has been placed additional weir components are installed in the following order:

1. To the support stand to be installed add a fence frame hanger to the vertical pipe on the side of the walkway which will have the fence panels (Fig. 3). The hanger can be suspended with rope and the KEE KLAMP can remain loose on the pipe (this allows users to set and adjust the fence panel frame height).
2. Add the walkway support to the support stand and tighten the cross-over KEE KLAMPS at desired height (Fig. 3). The first support stand should also have a walkway support in place.
3. Install the SS anchor pin into the outrigger leg of the support stand (Fig. 3). The pin can be temporarily held in the holder using a little duct tape on the pin and holder.
4. Carry the support stand past the last installed support stand and place upright and in line with the walkway.
5. Carry out two lengths of SHUR GRIP walkway and bolt side by side to the mid point of the walkway support of the support stand to be installed (Fig. 5).

6. Mount the boom and winch using a length of 3.81 cm pipe which will span the two vertical pipes of the installed support stand. To install the boom and winch follow the assembly instructions outlined in the boom and winch section of this report. The boom is positioned as shown in the top diagram of Fig. 5.
7. Pull sufficient cable from the winch and connect to a rope sling attached to the deck support bracket of the section to be installed.
8. Swing the boom into the deployment position shown in the bottom diagram of Fig. 5. The winch cable is then reeled in to drag out the support stand with attached walkway into position.
9. Bolt the SHUR GRIP walkway to the other half of the walkway support of the installed support stand.
10. Add a fence panel frame cradled in the pockets of the fence panel hangers that were added to the support stands.
11. Insert the conduit pipes into the fence panel.
12. Drive the SS anchor pins into the bottom substrate.
13. Extend the handrails using appropriate cross-over and straight coupler KEE KLAMPS.

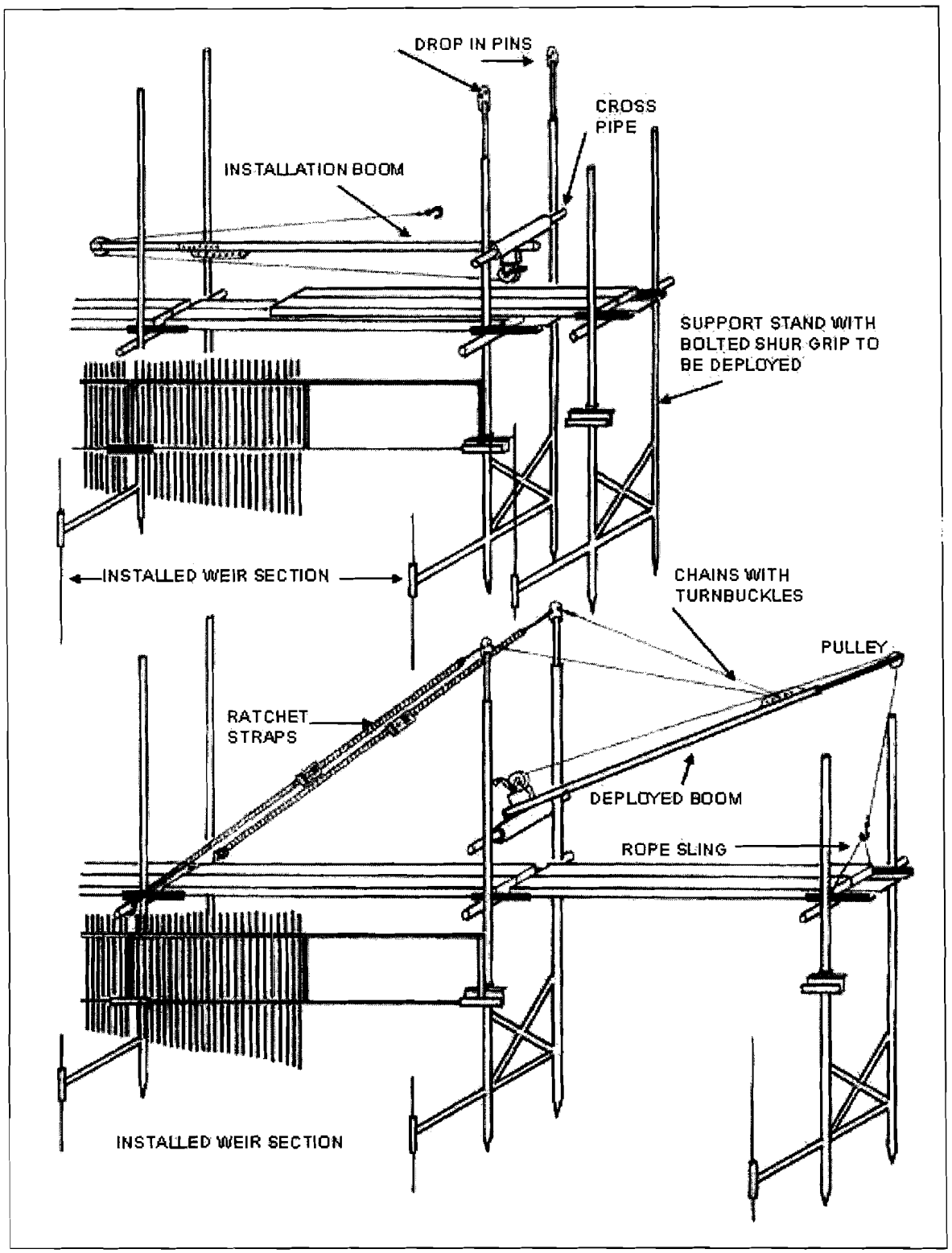

Fig. 5. Three-dimensional view of the sectional fish deflection weir, illustrating the installation and use of the boom and winch. The top diagram shows a support stand with attached walkway (Shur Grip) ready to be deployed. The bottom diagram shows the boom in a deployed position gabled with ratchet straps and chains. The handrail is not shown for clarity.

BOOM AND WINCH SYSTEM

We mount an extendable boom (4.0 to 4.6 m) equipped with a two-way winch to the offshore end of an installed weir section to add or remove further sections (Fig. 5). The boom is supported by a gable system of: 1) ratchet straps connected to two drop-in pins (1 m length) placed in the offshore vertical pipes of the support stand to a walkway support on the adjacent inshore section; and 2) chains with turnbuckles from the drop-in pins forward towards the end of the boom. Once installed the boom and winch acts as a crane and allows the user to pick up and move a weir section.

Construction

The boom is constructed of a 3.0 m length of galvanized pipe (6.0 cm diameter schedule-40) with a 2.0 m long extension (4.8 cm outside diameter) that fits inside the boom and is bolted at the desired length (Fig. 6). The extension has a 10 cm steel pulley bolted between two flanges at the end of the extension. A winch mounting platform (6 mm plate) is welded to the topside of the boom near its base. A two-way trailer winch equipped with 6 mm galvanized cable and a swaged on hook is attached to this mounting plate. A 6.0 cm diameter x 36 cm long galvanized pipe is centered on the underside of the boom and welded at a right-angle. This pipe has two 10 mm SS lock bolts that thread into the pipe and are used to lock the boom into its basal support during deployment.

Each drop-in pin is constructed of 1.0 m long (3.5 cm outside diameter) galvanized pipe with a 5 cm x 10 cm long (6 mm thickness) plate welded at one end. The plate has two holes (20 mm diameter) for mounting a turnbuckle hook and a ratchet strap hook.

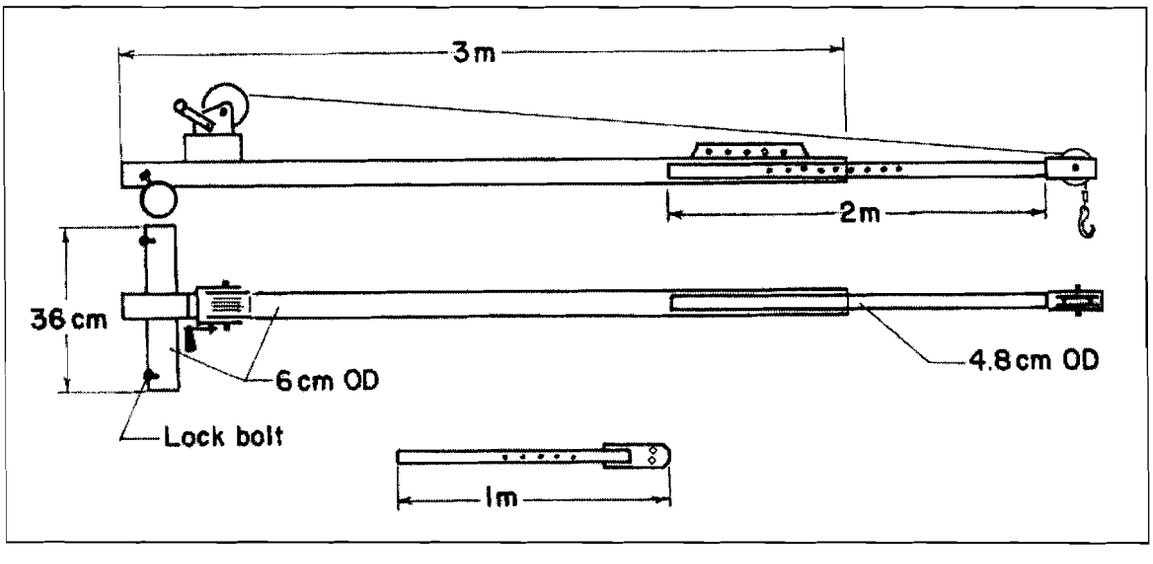

Fig. 6. Installation boom and winch used to add or remove sections of the Sectional Fish Deflection Weir. The top and middle drawings are a side and top view respectively. The bottom drawing shows a drop-in pin used to support the boom during deployment.

Assembly

The boom and winch are usually mounted on the last installed support stand before a new section is added. If a weir section is to be removed, then the boom would be set one section closer to the river bank. Assembly is in the following order:

1. Carry the boom to the end of the walkway with the pulley end towards the shore (Fig. 5 top diagram).
2. Place a cross-over KEE KLAMP (Fig. 2) onto each vertical pipe of the support stand below the handrails. This can be done by temporarily removing the handrail from its cross-over KEE KLAMP letting it drop and then replacing the handrail into the newly added KEE KLAMP.
3. Run a cross pipe (3.81 cm x 1.0 m) through one KEE KLAMP, the base of the boom (36 cm long pipe) and second KEE KLAMP. The boom should be resting upside down (Fig. 5 top diagram).
4. Add the 1 m drop-in pins to the support stand and attach the ratchet straps to the pin and the walkway support of the previous weir section.
5. Attach the chain and turnbuckle to each drop-in pin connecting both chains to a shackle placed in holed bracket provided near the end of the boom.
6. Pull out sufficient cable on the winch and attach the hook to the rope sling placed on the walkway support to be lifted. Swing the boom outwards to the deployment position (Fig. 5 bottom diagram) and tighten the two lock bolts. The boom is now supported by the chains and ratchet straps.

COSTS

The approximate costs to construct the sectional fish deflection weir components and installation boom are shown in Table 1. We show both the estimated cost per 3.7-m weir section and the costs for five complete sections shown in Fig. 1. All figures are in 2005 Canadian dollars.

Table 1: Approximate cost for a sectional fish deflection weir and installation boom.

Item	Description	Cost for 1st section	Cost for 5 section weir
Support stand	(2) required per 3.7 m weir section	$680	$2,040
Walkway support	(2) - includes stainless steel (SS) bolting platform and bolts	$260	$780
SHUR GRIP	(2) - (5 cm x 30.5 cm x 3.7 m)	$280	$1,400
Anchor pins	(2) - SS (16 mm x 3 m length)	$140	$350
Fence frame hanger	(2) – SS and comes with cross-over KEE KLAMP	$200	$600
Fence panel frame	(1) – Aluminium (0.9 m x 3.7 m)	$450	$2,250
KEE KLAMP	Cross-over, straight and 45° fittings	$240	$1,200
Handrail	(2) – galvanized pipe (3.81 cm schedule-40 x 6.4 m length)	$100	$300
Conduit pipe	(72) – galvanized (19 mm x 3 m)	$790	$3,960
Installation boom	Includes winch, cable, hook, ratchet straps, chains, turnbuckles and drop-in pins	$700	$700
	TOTAL	**$3,840**	**$13,580**

DISCUSSION AND CONCLUSION

The sectional fish deflection weir is an effective method of diverting fish passage to an area where they can be counted visually or with acoustic systems. The sectional weir can be installed and removed easily and relatively quickly and is inexpensive compared to bulkier permanent structures. Typically two people can install a five section weir in approximately 1-2 days. Based on our experience since it was originally designed in the mid-1990s, we have found that this weir is adaptable to various bottom contours because individual conduit pipe is placed in but not fixed to the fence panel frame thus conforming to the bottom profile. The walkway and handrails along the entire length of the weir provide safe access for cleaning, visual counting of fish passage and access to acoustic equipment deployed from the weir. Debris can be removed from the weir by

simply removing the appropriate conduit pipes and allowing the debris to pass downstream.

The weir presented in this paper is capable of operating in water up to 3.0 m deep and in current velocities as high as 2.5 $m \cdot s^{-1}$. We have deployed a similar weir for the Pacific Salmon Commission on the left bank of the Fraser River at Mission, BC, which typically is 40 m long at its maximum extent. Photo 1 shows 22 m of the weir installed at Mission in 3 m deep water with additional sections to be added as the river level recedes. Weir sections are installed using the boom and winch, eliminating the need to use boats or enter the water and resulting in a safer working environment for site personnel.

Photo 1. The sectional fish deflection weir operated by the Pacific Salmon Commission at their hydroacoustic facility at Mission, BC, on the Fraser River. Water depth at the end of the weir is 3.0 m and is considered the maximum operating depth for this weir design.

If current velocity is high when the weir is installed, then a diagonal brace can be added to the downstream side of each weir section (Fig. 1) even after the weir has been installed. The 3.0 m working depth is the maximum depth for this weir design. However deeper depths could be achieved with modifications to the support stands. The modifications for depths > 3.0 m consist of lengthening the support stands, increasing the width between vertical pipes of the support stands and extending the length of the outrigger leg.

The weir design described in this report can be modified to provide a counting platform above the walkway height using additional KEE KLAMP, pipe

and wider walkway supports (Photo 2). The weir design could also be used for counting downstream migrating juvenile salmonids by adding mesh to the fence panel frame instead of using the conduit pipes. The fence panel frame would be lowered and sandbags or additional mesh added to fill in open areas created by uneven bottom contours.

Photo 2. The sectional fish deflection weir with a visual counting tower added above the walkway and used to count migrating adult salmon on the Thompson River at Spences Bridge, BC.

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