River Etne Resistance Board Weir

Operations and Safety Plan

Prepared by:

Cramer Fish Sciences

Prepared for:

Marine Harvest Norway

April 2013

CRAMER
FISH SCIENCES

TABLE OF CONTENTS

I. BACKGROUND

Resistance board weirs have been used for over 20 years in the United States, primarily in Alaska, and more recently, in Oregon and California, for counting and assessing salmonid during the upstream migration (immigration) phase of their life cycle. Their popularity and utility as a monitoring and management tool continues to grow in the United States and other countries where migratory salmonids occur. By design, resistance board weirs are relatively non-invasive structures that allow for recreational passage and river user safety. In contrast to rigid structures such as picket weirs and low-head dams, resistance board weirs have the ability to "collapse" or fold down in the downstream direction during high flow or debris load conditions. This allows excess water and debris to pass over the top of the weir structure, thereby reducing the likelihood of damage or blowout. This is a relatively large benefit compared to rigid picket weirs that reach a breakpoint and either blowout or otherwise become severely damaged.

Relatively simple installation and removal are important features of a resistance board weir. No concrete pilings or other permanent structures are necessary. Panels made of polyvinyl chloride (PVC) and ultra-high-molecular-weight (UHMW) plastic are the primary structural weir components. These panels can be quickly installed and removed by hand by a few technicians, and the entire weir and associated components can be installed or removed in approximately 2-3 days.

The River Etne resistance board weir project is located in the Sunnhordland region of Norway. The river supports minimal boat traffic and moderate recreational use including a valuable sport fishery for Atlantic salmon (*Salmo salar*) and sea trout (*Salmo trutta*). Modifications to the weir structure will allow for safe boat passage over the top of the weir and free fish passage during non-operational periods. Public and field crew safety is the highest priority for the project, as well as the protection of the natural resources of the River Etne and measures have been incorporated into the weir design and operational procedures to minimize potential public safety risks. This *Operations and Safety Plan (Plan)* provides information and procedures for weir operation, maintenance, and preventative safety measures to make operation and field activities associated with the weir as safe as possible and to support the collection of accurate and unbiased scientific data. This *Plan* also details information regarding potential risks of weir operation and recommended actions to minimize those risks; fish protection and husbandry; and it supports human and resource safety. This *Plan* does not circumvent state, federal, local or other regulations as they pertain to personnel safety and protection of public resources. The operator is responsible to ensure that regulatory and safety compliance is met. Improper installation and operation of the weir can be dangerous or deadly to staff operating the equipment, the public, and the fisheries resources entrusted to the crew operator(s). The weir should never be deployed or operated without proper training and safety measures in place or an adequate crew.

II. SAFETY GUIDELINES

Public

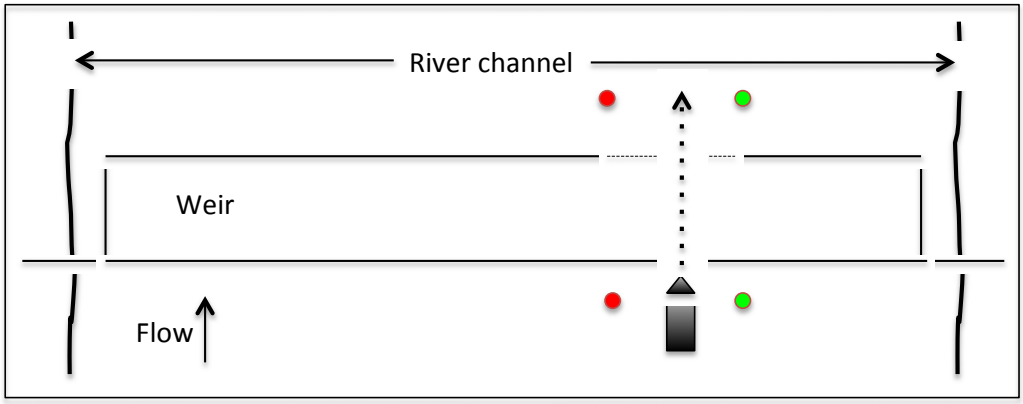
Notification and education will support the dissemination of weir information to the community and inform local water users regarding the availability of safety guidelines for navigating past the

project area. Primary measures include posting informational signage in the vicinity of the project site where recreational users (e.g., fishermen, rafters, canoeists, and other members of the general public) on the River Etne will encounter the weir. Educational flyers, pamphlets, or a kiosk at the weir site can increase public awareness of the project. Weir operators should also be prepared to discuss the project with the public encountered while on-site. A web site detailing the weir project may also provide a venue to share information with the community.

In addition to informative signage and handouts at the weir site, warning signs should be located upstream and downstream of the weir along the riverbanks. Examples of sign verbiage and

placement locations are provided below (Table 1 &

NOTICE	**MERKNAD**
CHANNEL OBSTRUCTION 2.0 MILES DOWNSTREAM PASS WITH CARE	CHANNEL HINDRING 3.0 KILOMETER NEDSTRAUMS PASSERE MED CARE



Boat Passage Instructions:	Båt Passage Instruksjoner
When passing the weir in either the upstream or downstream direction: • Approach area with caution and observe the posted “No Wake” zone • Keep speed at or below 5 MPH • Be aware of areas of shallow water • Remain between channel markers • Raise motor to shallow drive position • Carefully pass over weir	Når passerer weir i enten oppstrøms eller nedstrøms retning: • Tilnærming med forsiktighet og observere "No Wake" sonen • Hold farten på eller under 8 KPH • Vær oppmerksom på områder med grunt vann • Seg mellom ledmerkene • Hev motor til grunne kjøreposisjon • Nøye passere over weir

Figure **1**). Signs should be at least 0.5-m x 1.0-m in size with large lettering; however, larger signs are more noticeable and should be considered where feasible. Lettering should consist of bold reflective letters on a reflective white background to increase visibility during low light conditions.

Table 1. *Example of warning sign verbiage and approximate placement distances both upstream and downstream of the weir project site.*

Sign Location (upstream and downstream of weir)	Wording (Norwegian)	Wording (English)
100 m	**ADVARSEL** FARLIG UTSTYR AHEAD TILNAERMING MED FORKSIKTIGHET	**WARNING** DANGEROUS EQUIPMENT AHEAD APPROACH WITH CAUTION
25 m	**FORSIKTIG** NO WAKE S ONE 8 K.P.H.	**CAUTION** NO WAKE ZONE 5 M.P.H.
15 m	FORBLIR MELLOM LEDMERKENE TRIM MOTOR PASSERE MED CARE	REMAIN BETWEEN CHANNEL MARKERS TRIM MOTOR PASS WITH CARE

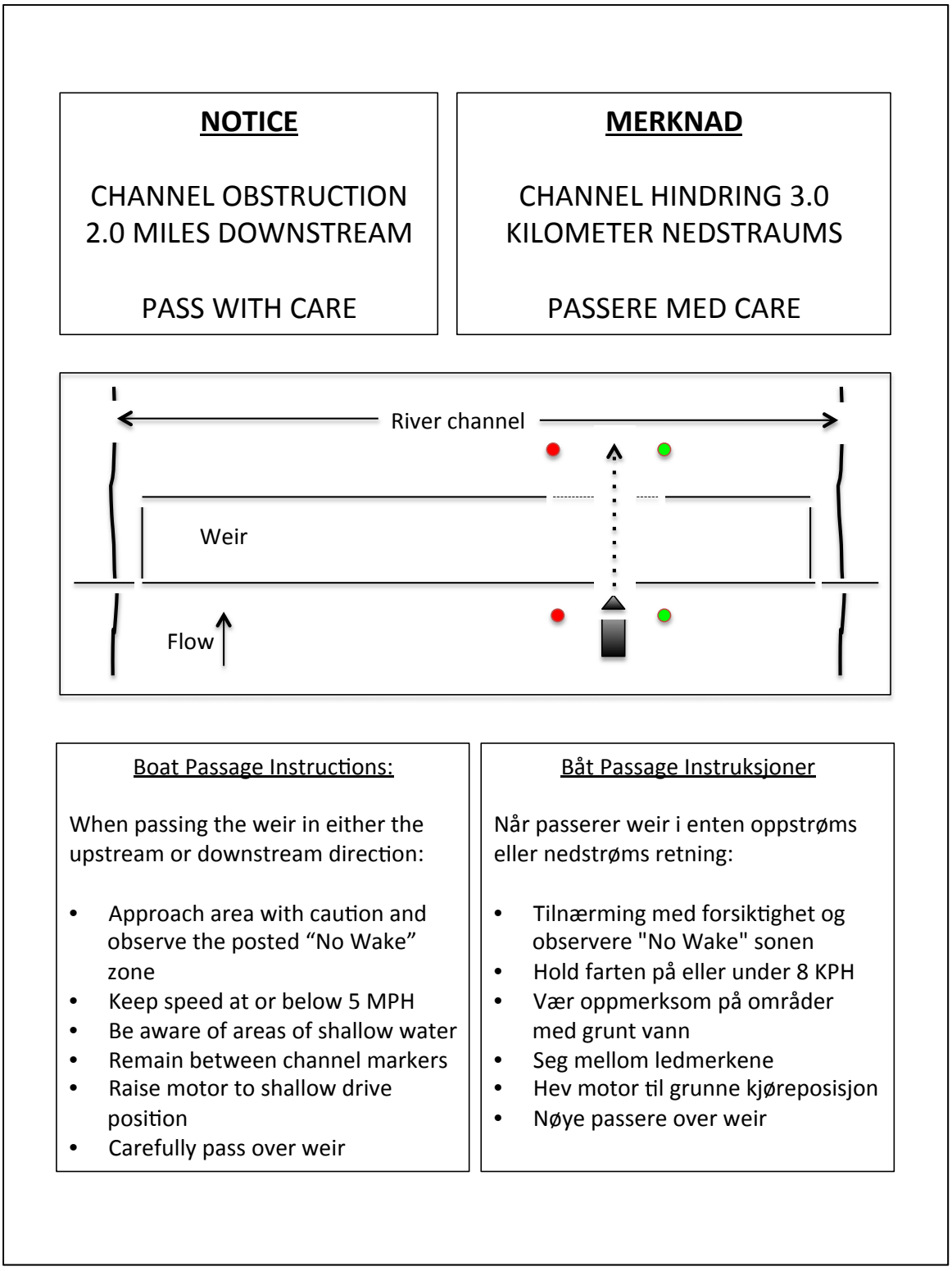


Figure 1. *Example of warning signs that could be placed at river entry points (i.e., boat launch, etc.).*

Regulatory buoys and channel markers should be strategically placed within the river channel at the project site in accordance with state, federal, county, and local waterway regulations. These should be oriented to work in conjunction with the onshore warning signs to provide boaters with clear instructions on how to safely pass the weir. Two white-and-orange float collar can-type buoys labeled with the standard orange diamond (caution) symbol used in the state marking system, along with the words "SLOW NO WAKE" should be used (i.e., 25 m above and 25 m below the weir). Float collar buoys are better suited for shallow water areas instead of the taller concrete-ballasted buoys found in most lakes. An example of the buoy design is shown below (Figure 2).

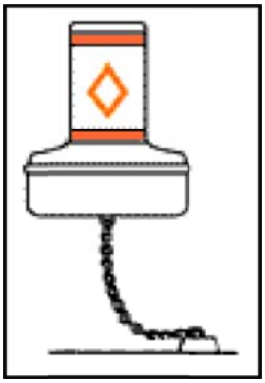


Figure 2. *Example of a float collar can-type buoy. Image copied from* www.rolyanbuoys.com.

Multiple channel markers should be placed in a string starting 10 m upstream and downstream of the weir on each side of the boat passage area. Follow local regulations for marker type and color.

The two caution buoys (i.e., one 25 m upstream and one 25 m downstream) will have flashing amber safety lights mounted on top. Additional safety lights can be mounted on the right and left bulkheads and the live fish trap to identify the edges of the weir. Safety lights will also be mounted on the edges of the boat passage panel to mark the area for passage under dark (nighttime) conditions.

External lighting to help illuminate the weir structure at night is advised in case of an emergency. Solar powered motion detection lights work well in areas where direct power is unavailable. Sites with direct power have a wide range of spotlight and floodlight options.

Weir Personnel

Safety should always be the primary concern of personnel installing, operating, maintaining or dismantling/removing the weir. Safe, healthy employees will support the collection of valuable and trustworthy data and ensure the safe and effective operation of the weir and its components. Never perform a task if it cannot be performed safely. Stay aware of your surroundings and possible hazards at all times. Make suggestions about improvements to safety procedures to co-workers in the field or the Project Lead.

Trained technicians maintaining the weir should wear waders or dry suits with non-slip wader boots, and an approved personal floatation device (PFD) while in or near the water. Waders

should fit snugly, and a wader belt should be used at all times. Always work in teams of two or greater, and know where your team members are while on-site. If working at night, technicians should wear headlamps or other light sources that allow their hands to be free to work. Neoprene gloves are recommended when working in cold water and cleaning/maintaining the weir. Staff working on the weir should be trained in first-aid/cardio pulmonary resuscitation (CPR), and should know how to swim. At least one crewmember should have a working cell phone or other communication device when in the field.

First aid kits, emergency road flares, and fire extinguishers should be maintained in all vehicles and boats. The weir team should be aware of the dangers of working in the natural environment, including hypothermia, hyperthermia, cold and swift water, and lightning strike injuries. It is recommended that the weir operators develop a full employee safety program, including standardized first aid program, CPR training, and Injury and Illness Prevention Program. These subjects are beyond the scope of this *Plan*.

III. RESISTANCE BOARD WEIR OPERATION

General Operation

The resistance board weir consists of six (6) principal components: (1) weir panels, which form the barrier, (2) a substrate rail, which anchors the panels to the river bottom, (3) passage chute to allow fish passage through the weir, (4) bulkheads and fixed pickets to prevent fish from passing around either side of the weir, (5) modified boat passage panels to allow boat traffic over the weir, and (6) 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 wide array of 3' wide x 20' long (~0.9m wide x 6.1 m long) tubular PVC pickets. Each picket is sealed at both ends for flotation and 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:

(1) substrate rail, (2) weir panels, and (3) live trap. Work may begin as soon as river conditions allow. The weir 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.

Pre-Installation

The location of weir deployment should be chosen where the chances of bank erosion are kept to a minimum. Crews should be careful not to damage bank vegetation or cause bank erosion while working in and around the weir area. The project site and work area should be cleared and

prepped for installation of the weir in advance (Figure 3). The crew should have a pre-operation meeting to discuss safety, updates on new procedures, and insure that all employees are aware of safety and operational procedures. Equipment should be checked for any flaws, and worn-out, broken or missing pieces. The weir panels require close inspection each season before installation. A material checklist should be used to ensure all equipment and tools are present and in good working order.

Figure 3. *Before (left) and after (right) photographs of a weir site work and staging area.*

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 periods of high flow (Figure 4). But because winter and spring ice conditions can be destructive, this strategy only works at sites with moderate winters without thick ice. If normal wading conditions can be anticipated near the beginning of the operational period, the best strategy is to leave the rail installed after each field season.

Figure 4. *Clearing excess sand and gravel deposited on top of the substrate rail during high flow (spring) conditions (left); and attaching the substrate rail cable (right).*

Installation

Resistance board weir installation generally takes 2-3 days with a trained crew of 4-6 persons. Installation time depends on weir size, location, and site characteristics. To begin installation, lay out the substrate rail location by stretching a small cable or string across the river to stakes on each bank (**Feil! Fant ikke referansekilden.**5). This will create a straight line to guide substrate rail installation. Start on one side of the channel by placing one section of rail at a time. To secure each rail section to the river bottom, drive the rebar pins through the holes on the ends of each leg along a substrate rail section (**Figure**6). Attach the subsequent rail section to the previous section and continue this installation pattern until you reach the opposite bank.

Figure 5. *Use of a reference line, such as a cable or string, stretched across the river to guide substrate rail installation.*

Figure 6. *To secure each rail section to the river bottom, drive the rebar pins through the holes on the ends of each leg along a substrate rail section.*

After the substrate rail has been installed and secured to the river bottom (Figure 7), string the steel substrate rail cable through the eyelets located along the length of the substrate rail. Attach the tag end of the cable to itself on the far bank, and then tighten the opposite end of the cable until it is stretched tautly. After the cable is under tension, place a cable clamp in front of the first eyelet to hold the cable in place. Next, wrap the cable back onto itself and securely fasten it with additional cable clamps.

Figure 7. *Installed substrate rails across river channel and substrate rail leg with inserted pin.*

Next, install the first rigid weir along the far bank by installing an A-frame and associated rigid weir panel sections (**Figure**8). Then install the first bulkhead and adjacent posts used to brace

the bulkhead. After the bulkhead is in place, the first resistance board panel can be hooked onto the substrate rail cable; this process continues across the extent of the river channel (Figure 9). A single PVC connector picket is used to connect adjoining resistance board panels.

Figure 8. *Installed A-frame, associated rigid weir panel, bulkhead and first resistance board panels.*

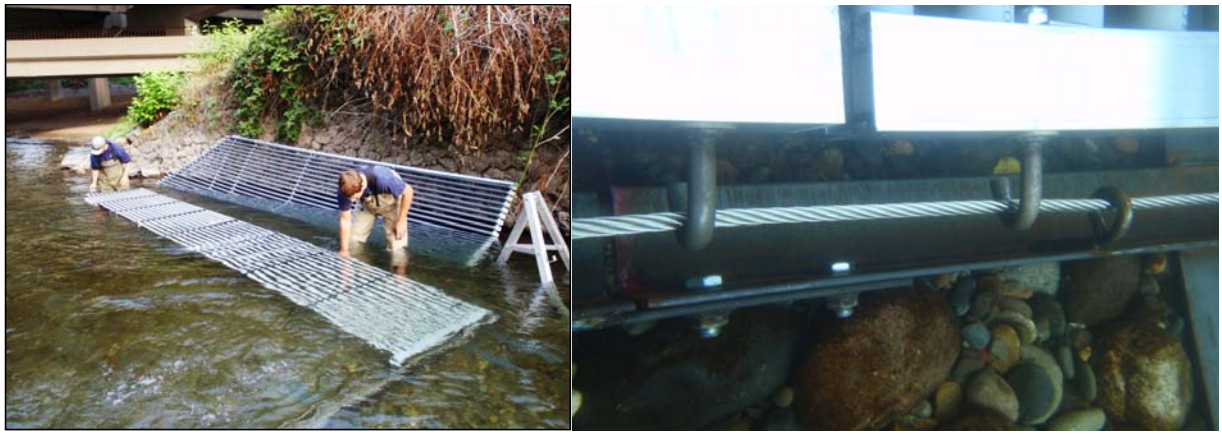


Figure 9. *Resistance board panel hooked onto the substrate rail cable.*

Run the picket through the stringers of two adjoining panels and secure in place using a hose clamp. Do this with each successive panel (Figure 10). Continue with regular panels and install the modified upstream passage chute panel when the location of the live trap is reached. Continue across the rest of the channel with regular panels up to the location where the second bulkhead is to be installed. Follow the above procedures to install the rigid weir and A-frame section to make the connection with the near bank.

Figure 10. *Inserting a connecting picket between two adjoining panels (left); continuing across the river channel (right).*

After all resistance board panels have been successfully installed, go back and install the boat passage cap panel in a location where boaters would likely pass over the weir (Figure 11). The purpose of the boat passage panel is two fold; first, it is designed to allow boat traffic to pass the weir in both and upstream and downstream manner, and second, it provides protection to the resistance board panels from boat traffic damage. The ability for recreational users (e.g., boats, canoes, rafts, swimmers) to safely pass over the weir structure is a significant advantage for minimizing impacts to recreational river users (Figure 12).

Figure 11. *Completed weir installation (minus live trap)(left); installation of the boat passage cap panel (right).*

Figure 12. *Inflatable kayak passing a weir (left); inboard jet boat passing a weir (right).*

Next, set the resistance boards for each panel as needed (flow dependent). This entails pushing the board in a downward direction, then securing it by hooking the cable button stop to the resistance board harness stay. Each resistance board panel has two resistance board cables attached to it. Each cable is outfitted with three button stops to adjust the angle of the board relative to the flow. Higher flow will require a steeper board angle.

At this point, weir installation is nearly complete. Installing the live fish trap occurs next (Figure 13). Start by leveling the river bottom substrate where the trap will be placed. Next, install each side panel in number sequence. After the outside frame has been erected, install the floor grating sections. Finally, complete the trap installation by installing the removable trap lids. At this point, a connection must be fabricated between the exit of the passage chute panel and the entrance to the live trap. This is completed using PVC, plastic mesh, and zip ties. Next, the substrate rail cable cap must be installed along the entire width of the weir to protect fish from injury along the cable. The cap is made of ripped-in-half ABS plastic that is fastened to the substrate rail cable itself. To reduce the chance for scour along the leading edge of the substrate rail, it is a good idea to line its length with sand or gravel bags. Finally, install directional buoys, safety lights, and warning signs above and below the weir site as needed.

Figure 13. *Initial assembly of the live trap frame (left); completed live trap installed (right).*

Maintenance

The weir should be cleaned on a regular basis (e.g., once daily). The flow volume and debris loading will determine maintenance intervals. A pair of technicians can walk across the weir to partially submerge each panel, thus allowing the current to wash most debris downstream. Technicians can use a metal rake, stiff bristle brush, or their hands to clear away additional debris, and to dislodge larger debris from the weir (Figure14). Conduct visual inspections of the weir panels, substrate rail, fish trap, and fixed weir sections each time the weir is cleaned to ensure there are no breaches. If conditions prevent an adequate visual inspection, technicians should use snorkel gear to visually inspect the weir. Large pieces of debris (i.e., large trees, chunks of ice, etc.) can be physically rolled off of the weir panels in a downstream direction. The object must be staged in such a way that it won't damage the panels when it is rolled off. Technicians can manually lift and roll an object, or if too heavy, a gas powered boat or winch can be used.

Figure 14. *A technician cleaning debris from a weir using a stiff bristle brush (left); and grabbing and tossing leaf litter over the back of a weir during a high flow event (right).*

Repairs

Repairs to various parts of a resistance board panel are necessary, both during and after each field season. Repairs done while the weir is in river and operational are generally short-term repairs. Once the weir has been removed for the season permanent repairs, or replacement of a part, can be completed. Refer to Stewart 2002 for some weir panel repair tips.

Removal

The first step in weir removal is to drop all resistance boards to a flat (non-set) position (Figure 35). Next, begin breaking down the rigid weir structure on the far bank and work towards the resistance board panels. After the rigid weir has been removed, the first bulkhead can be removed. Next, remove the first resistance board weir panel by removing the connecting picket and then unhooking the panel from the substrate rail cable. Continue removing connector pickets and adjoining weir panels. Remove the boat passage panel. Panel removal can continue until the second bulkhead is encountered. Remove the bulkhead and the remaining rigid weir

panels. The substrate rail cable can be disconnected and removed for the season. The steel substrate rail can generally be left in place to reduce installation labor the following season unless removal is required for safety or regulatory reasons (Figure 16). All panels and equipment can either be stored on site or transported to a storage location and held until the following season. The resistance board weir panels should be stored indoors, or covered with a tarp to prevent sun damage when not installed in the river.

Figure 35. *Technician dropping the resistance boards of an individual panel to prepare a weir for removal (left); and view of a weir with part of the rigid weir already removed (right).*

Figure 46. *Technicians removing connecting pickets and unhooking a resistance board panel (left); and a weir site after removal with the substrate rail left in place (right).*

Storage

Once the weir has been removed from the river it needs to be cleaned and prepped for storage until its next use. Take time to clean all weir components by pressure washing and scrubbing built of algae off of the parts. Lube all hardware and cables. Make permanent repairs to broken parts or pieces at this time. Once the weir has been properly cleaned, repaired, and is dry it can be stored until the next field season.

To preserve the integrity of the weir components it is recommended for the weir and all of its parts be stored indoors. Ultraviolet light will break down PVC integrity over time, causing the PVC pickets to become brittle and break. Weak PVC will crack easily when stepped on or hit by a large piece of debris. Water collected inside of PVC pickets can freeze during cold weather and crack the PVC. To prevent sun and cold damage it is best to store the weir in a dry, covered area, preferably indoors. Resistance board panels, trap panels, and rigid weir panels can all be stacked on top of each other to reduce the amount of floor space required for storage. Resistance board panels can be stacked up to twenty panels high. Hardware and other loose items should be organized, labeled, and placed in a sturdy container. If indoor storage is not an option the entire weir should be covered with a heavy-duty tarp to reduce impacts from varying weather conditions and the sun.

IV. EXAMPLE PROTOCOLS

Trapping Protocol

- Close the fish trap exit door and narrow the fyke gate when a trapping period begins.
- Allow the trap to fish for a set period of time.
- Remove at least one lid from the top of the trap before entering the trap to process the catch.
- Collect environmental data (e.g., flow, dissolved oxygen, water temperature) during each trap check.
- Handle/process fish according to approved fisheries guidelines.
- If required, collect tissue and/or scale samples from species of interest.
- Measure the biomass of captured fish by using a hanging scale.
- Take a photograph of every captured fish, and measure its depth (mm), fork length (FL, mm), and total length (TL, mm) (*see* Larson 1995 for example of a fish cradle).
- Identify the species, sex, and presence/absence of an adipose fin (if applicable) for every captured fish (*see* Merz and Merz 2004 to help determine sex using morphological features).
- Note any injuries, hook scars, predator scars, fungal infections, indications of disease etc.
- After a fish has been processed, pass the fish to the outside of the trap and place it in a recovery area upstream from the weir.
- After a fish has fully recovered, it can be released to continue swimming freely upstream.

Fish Scale Collection Protocol

The collection of salmonid scale samples will occur as follows:

The best quality scales for ageing are located in an area known as the "scale pocket" or "key scale area" (Figure 57). Locate the scale pocket on the left side of the fish by following the diagonal row of scales down and back from the posterior insertion of the dorsal fin to the first 3 scales above, but not including the lateral line. One to two scales in front of (anterior) and behind (posterior) these three scales are within the key area (see Figure 57). If scales cannot be collected from this area, trying using the right side of the fish. If the right side also does not work, gather scales from above the lateral line within two centimeters of the key area.

- Wipe the sample area clean of mucus and dirt. If possible, pluck 4-5 scales from the key area with forceps. If not possible, remove approximately 10 scales with a knife by scraping in a tail-to–head direction within the key area.
- Wipe the scales onto the scale envelope insert (piece of wax, copy or lens paper), and place the insert in the scale envelope. Do not stack the scales.
- Record the scale sample number from the envelope on your data sheet, with all biological data (i.e., date, time, location, species, fork length, sex, ad-clip presence, head tag #, etc.).
- Ensure that the forceps are clean before sampling the next fish.
- Keep all scale samples organized and in a common location. Scales should be stored in a dry location with adequate ventilation. Tupperware containers with perforated lids can be used for daily deposition of samples. A large box is suitable for longer-term storage.

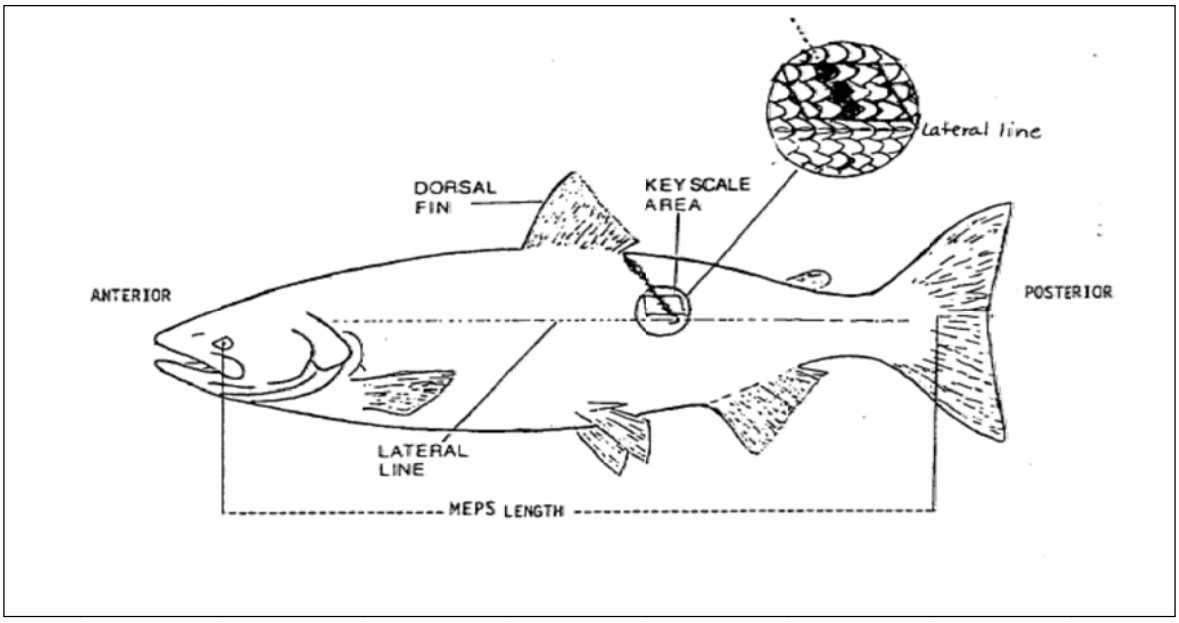


Figure 57. Schematic of the "scale pocket" or "key scale area" on a generic salmon.

Weir Field Crew Check List

- ☐ Clip board
- ☐ Waterproof field note book
- ☐ Trapping data sheets (waterproof)
- ☐ Snorkel survey data sheet (waterproof)
- ☐ Pocket knife
- ☐ Scale sample envelopes/water proof papers
- ☐ Forceps/tweezers
- ☐ Measuring tape; measuring board
- ☐ Pencils
- ☐ Black permanent marker
- ☐ Hand-held thermometer
- ☐ Stopwatch
- ☐ Water sample vial
- ☐ Species code sheet
- ☐ Trap keys
- ☐ Water velocity (current) meter
- ☐ Dissolved oxygen meter
- ☐ Metal rakes
- ☐ Stiff bristle brushes
- ☐ Digital camera and spare batteries
- ☐ Cell phone
- ☐ Mask/hood/snorkel gear
- ☐ Dry suit/waders
- ☐ Wader boots
- ☐ Dive gloves/booties
- ☐ Emergency medical kit
- ☐ Throw rope

V. REFERENCE MATERIAL

Larson, L. L. 1995. A portable restraint cradle for handling large salmonids. North American Journal of Fisheries Management 15:654-656.

Merz, J. E., and W. R. Merz. 2004. Morphological features used to identify Chinook salmon sex during fish passage. The Southwestern Naturalist 49(2):197-202.

Stewart, R. 2002. Resistance board weir panel construction manual. Alaska Department of Fish and Game, Division of Commercial Fisheries, Arctic-Yukon-Kuskokwim Region, Regional Information Report No. 3A02-21. Available: http://www.arlis.org/docs/vol1/57240706.pdf (March 2013)

Stewart, R. 2003. Techniques for installing a resistance board fish weir. Alaska Department of Fish and Game, Division of Commercial Fisheries, Arctic-Yukon-Kuskokwim Region, Regional Information Report No. 3A03-26. Available: http://www.arlis.org/docs/vol1/54404175.pdf (March 2013)

Tobin, J. H. 1994. Construction and performance of a portable resistance board weir for counting migrating adult salmon in rivers. U.S. Fish and Wildlife Service, Kenai Fishery Resource Office, Alaska Fisheries Technical Report Number 22, Kenai, Alaska. http://alaska.fws.gov/fisheries/fish/Technical_Reports/t_1994_22.pdf (March 2013).

Zimmerman, C.E. and L.M. Zabkar, 2007. Weirs. Pages 385-398 in D.H. Johnson, B.M. Shirer, J.S. O'Neal, J.A. Knutzen, X. Augerot, T.A. O'Neil, and T.N. Pearsons. "Salmonid field protocols handbook: techniques for assessing status and trends in salmon and trout populations". American Fisheries Society, Bethesda, Maryland. Available: http://www.stateofthesalmon.org/fieldprotocols/downloads/SFPH_p13.pdf (March 2013).