RECLAMATION Managing Water in the West

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The Knowledge Stream
Research Update

Using Electric Barriers for Returning Adult Salmonids

Can electric barriers be used to redirect upstream migrating adult salmon back to their natal stream?

Bottom Line

For this scoping-level research project, a literature review was conducted on the use of electric barriers for returning adult salmonids. The effectiveness of electric barriers at deterring migrating adult salmon; the effects of electricity on adult salmon health, stamina, and reproductive capability; and the effects of electricity on delta smelt and sturgeon were investigated.

Better, Faster, Cheaper

Based on the literature review, an electric barrier may be effective at diverting upstream migrating adult salmon in the Mokelumne River that might otherwise pass through the Delta Cross Channel into the Sacramento River. For this application, physical barriers are not feasible as they would restrict fish movement throughout the year and impede recreational activities. Other non-physical barriers may not be enough to deter adult salmon.

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Problem

Manmade diversions provide unnatural routes between river systems that may cause adult salmon to move away from natal spawning grounds. In these instances, poor hatchery return numbers or undesirable genetic mixing may occur.

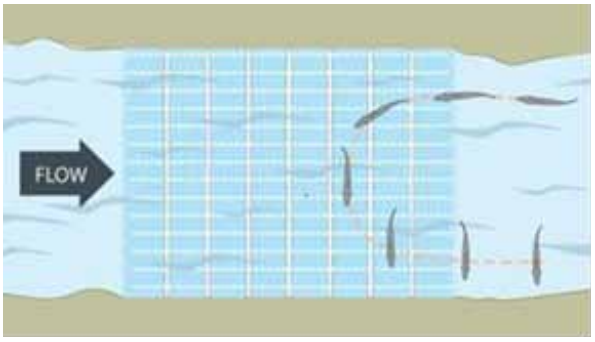
An electric barrier may be one possible alternative to redirect upstream migrating adult salmon back to their natal stream. An electric barrier has been proposed to prevent upstream migrating adult Chinook salmon (*Oncorhynchus tshawytscha*) in the *Mokelumne* River from moving into the Sacramento River when Delta Cross Channel gates are open in the fall. Electric barriers may also be considered for returning adult salmon at other locations in Reclamation's Mid-Pacific and Pacific Northwest Regions.

To determine if an electric barrier may be a safe and effective way to deter migrating adult salmon, a targeted literature review was needed to answer:

- Have electrical barriers been installed for this purpose?
- How were the barriers designed?
- Were the barriers effective? If not, what were the problems?
- Does electricity affect adult salmonid health, stamina, or reproductive capability?
- How does electricity affect delta smelt (*Hypomesus transpacificus*) and sturgeon (in particular, green sturgeon—*Acipenser Medirostris*), since these federally protected species may be present in locations where electric barriers are installed to guide adult salmon?

Solution

Electric fish barriers are commercially available and have been used in a variety of situations including the restriction of fish movement during upstream passage. When carefully designed, electric barriers can be effective for a wide range of channel widths and water depths and for a range of target fish species. If an upstream moving fish is stunned by the barrier, water velocities must be high enough to move the fish downstream from the barrier to recover. Deterred fish should have a clear path back to the preferred migration route.



Schematic of a graduated electric field fish barrier where a fish is immobilized, swept downstream, and recovers movement. Image created by, and courtesy of Smith-Root, Inc. (www.Smith-Root.com).

Alternating current was used in early fish barriers, but this has since been found to be injurious to fish. Direct current (DC) or pulsed DC is typically used in recent fish barrier applications. When pulsed DC is used, peak voltage, peak current, pulse width, and frequency are adjusted to elicit the desired fish response. Electrodes can be flush-

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mounted on the river bottom, installed as vertical drops suspended from a cable, attached to pilings, attached to buoys at the water surface, or suspended mid-depth in the water column. Large fish are generally more susceptible to electrical fields than smaller fish because more power is transferred for a given voltage gradient (volts per unit distance) over the length of the fish. Maintaining field intensity low enough to avoid tetanus in larger fish should also allow smaller fish to pass through the field unharmed.

Smith-Root, Inc. (Vancouver, Washington) has developed a graduated field fish barrier. To redirect upstream migrating fish, the voltage gradient progressively increases as the fish moves upstream through the barrier. This design allows fish to turn away from the field while experiencing minimal discomfort, but causes significant discomfort as fish progress through the barrier. Since fish of concern may come in contact with the barrier from the upstream side, it may be appropriate to graduate the voltage gradient on the upstream end as well.

Electric barriers pose certain safety risks to commercial vessels, recreational boats, and people in the water in the vicinity of the barrier. However, electric barriers can be designed to be non-lethal to humans and fish by using low frequency pulsed DC. Boats can safely pass through barriers without harm to occupants when safety requirements for each specific site are followed.

Delta Cross Channel gates in the open position, California.

Electric barrier with bottom flush-mounted electrodes at Quinault National Fish Hatchery, Washington.

The literature review search did not uncover any studies with the same application as the project at the Delta Cross Channel. Several fish hatcheries in the Pacific Northwest use some type of electric barrier to divert adult salmon towards the hatchery. Although electric barriers are likely successful at obtaining return numbers to the hatcheries, published information regarding their efficacy as an exclusion barrier is limited. In various situations, DC barriers have been shown to reduce upstream migration of sea lamprey, common carp, and grass carp and a hanging electrode alternating current (AC) array has been shown to reduce upstream migration of salmon.

Few studies are available regarding the effects of electrical exposure to sturgeon. Some injuries were recorded, but voltage and frequency levels were higher in literature than what would be used in a graduated field fish barrier. Soft-start pulsing to disperse fish near electrodes should be considered if sturgeon are expected near the proposed barrier location. Additionally, no information is readily available regarding effects of electric barriers on delta smelt. However, the electrical settings necessary to divert larger fish such as salmon and carp without injury should not cause adverse effects to smaller fish such as delta smelt. Electrical exposure to the eggs of sturgeon and delta smelt could reduce viability; however, unless sturgeon or delta smelt are spawning in the vicinity of the electrical barrier, it is unlikely that their eggs would be affected. Regulatory agencies should be contacted to determine if federally listed fish and their eggs or larvae will be present in the proposed location of the electric barrier during the operation period.

"Electric barriers may be an effective alternative to redirect upstream migrating adult salmon if a clear path back to the preferred migration route is provided."

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Collaborators

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Future Plans

This literature review can be used by personnel considering the installation of an electric barrier for their project. Although no studies were found where a DC electric barrier was used as an exclusion barrier for upstream migrating adult salmon, this literature review indicates that an electric barrier could be successful at achieving project goals for the proposed Delta Cross Channel barrier. Installing an electric barrier to divert upstream migrating adult Chinook salmon away from the Delta Cross Channel should be further investigated.

More Information

www.usbr.gov/research/projects/detail.cfm?id=9447