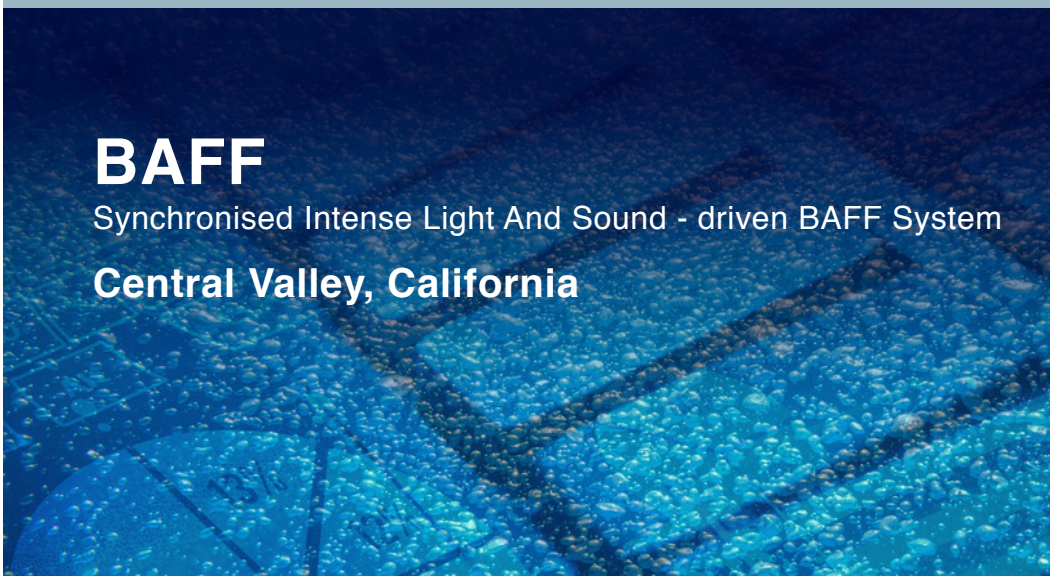
CASE STUDY



BAFF

Synchronised Intense Light And Sound - driven BAFF System

Central Valley, California

Need for a Fish Barrier

The San Joaquin River (SJR) (California, USA) supports an endangered stock of anadromous Chinook salmon (*Oncorhynchus tshawytscha*), a species that smoltifies and runs to sea in its first year via the San Francisco Delta. As it descends towards the Delta, the SJR channel splits, with around 75% of spring flow entering the Old River branch, and 25% remaining in the SJR channel. Chinook smolts entering the Head of Old River (HOR) have a lower chance of making it out to sea, owing to the use of this channel for irrigation of the surrounding rich agricultural land. There is consequently a risk of significant entrainment losses into irrigation pumps. The hybrid SILAS driven BAFF system was installed to divert fish from flow streamlines entering the HOR into the safer waters of SJR.

Figure 1

Plan view of the Head of Old River bifurcation, showing fish barrier line and the positions of the four fish-tracking hydrophones (coloured dots).

Barrier Design

The system selected was a multi-stimulus fish barrier, a Bio-Acoustic Fish Fence (BAFF), with the bubble curtain also illuminated by High Intensity flashing Lights (HIL) based on low-voltage (50V) light-emitting diode (LED) technology. LEDs are safer and more convenient to use than conventional high-voltage xenon strobes; the lights also have high reliability and much longer working life. The HILs were attached at the base of the BAFF to illuminate the bubble curtain. Prior to its installation at HOR, the barrier design was tested with Chinook salmon in a purpose-built flume model of a river channel at the US Bureau of Reclamation (USBR), Denver. The Sound Projectors and LED flash rate were tuned to known sensitivities of these species. The barrier was shown in the lab tests to divert Chinook smolts with an efficiency of up to 63.1%.

The river width at the barrier line was 91 m, depth 2.5-4.5 m and average flow velocity 0.41 ms-1. The barrier length in the first deployment (2009) was 112 m, this being extended in 2010

Fish Guidance Systems

Unit 7
Swanwick Business Centre,
Bridge Road,
Lower Swanwick,
Southampton,
SO31 7GB UK

Phone:
+44 (0)1489 880420

Email:
fgs@fish-guide.com

Web:
www.fish-guide.com

to 136 m. The layout of the barrier was based on an angled design, in which the barrier was aligned diagonally across the river at 24 degrees to the flow, thus guiding fish along its face to the downstream end. The angle of the barrier determines the swimming speed required of the fish to enable their escape ('escape velocity') and was chosen to be below the critical swimming speeds of Chinook smolts.

The 2009 barrier comprised the following active sound, light and bubble generating components, these being expanded pro rata for the 2010 deployment:

- 56 off Sound Projectors (Fish Guidance Systems, Model FGS MkII 15-100) spaced at 2 m intervals along the barrier;
- 112 off 1 m-length high-intensity light bars;
- 7 off (+ 1 spare) audio power Amplifier/ Control Units (Fish Guidance Systems, Model FGS 400);
- 1 off acoustic fish deterrence Signal Generator (Fish Guidance Systems, Model FGS 2-08);
- Associated cable harnesses and power supply units;
- 250 m high-pressure perforated rubber tubing (for bubble curtain);
- 1 off (+ 1 spare) high capacity trailer-mounted diesel-powered air compressor.
- Supporting lattice and pile structures.

Fish Diversion Efficiency

Movements of Chinook salmon past the barrier were monitored using an acoustic tag tracking system with four underwater hydrophones located around the barrier zone (Figure 1). The tags allowed a track to be plotted as the fish passed through the hydrophone array, showing whether the fish entered the HOR or SJR routes, allowing barrier efficiency to be measured during alternate periods with the barrier turned on or off. Examples are shown in Figure 2. Some fish were seen to cross the NPB line to enter Old River (e.g. Figure 2a – in which the fish barrier was "Off"), while others were deterred by the operating barrier (Figure 2b).

The overall Deterrence Efficiency when the fish barrier was operating was 81.4 percent which represents the proportion of fish heading towards the SJR channel.

For further information on fish deflection systems please contact FGS.

Figure 2 Examples of 2D fish tracks obtained from acoustically tagged smolts. The NBP line is shown as red when 'Off' and green when 'On'. The fish track is shown in yellow/orange.

Figure 2a Fish passes NPB (barrier off)

Figure 2b Fish deflected by operating NPB

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