

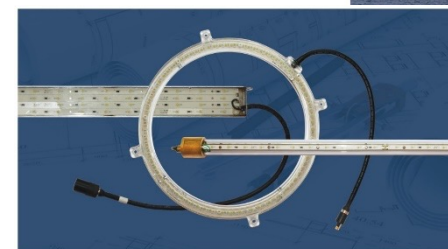
The installation of a behavioural barrier for smolt migration, from initial design to final deployment

IFM International Fish Impingement and Entrainment
Conference – 12 July 2023

Dr David Lambert
Managing Director

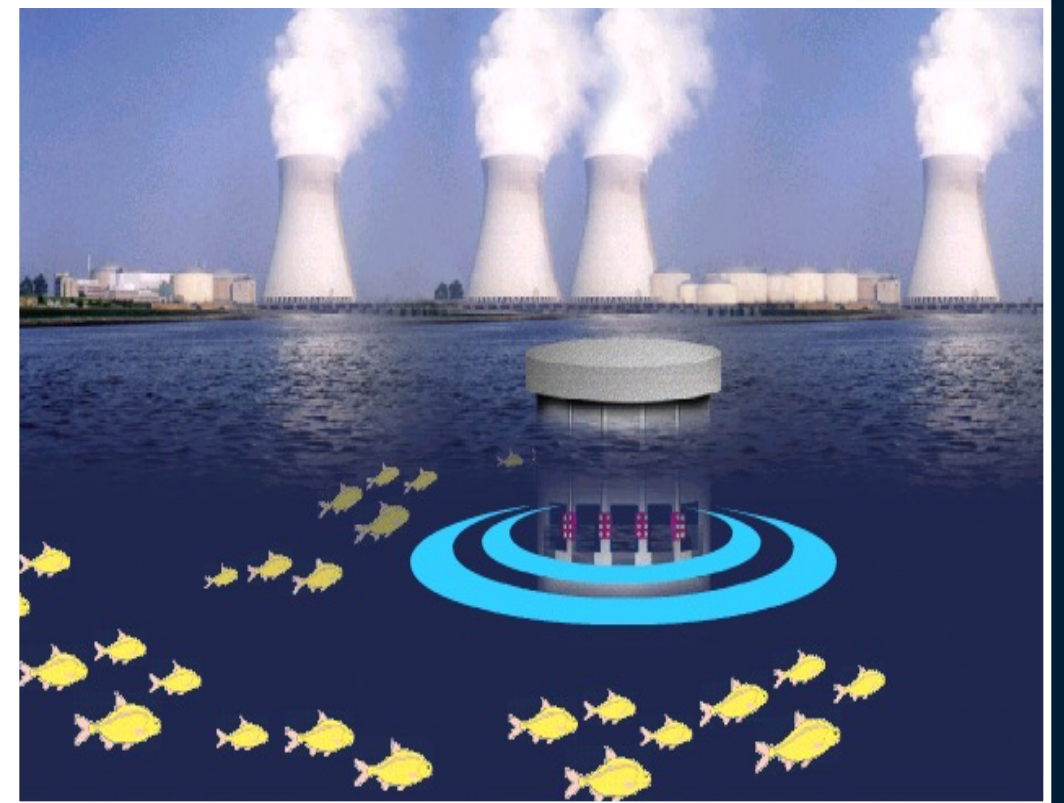
Fish Guidance Systems

- Established 1994
- Pioneered the development of acoustic fish deterrent systems
- Number of systems now available from FGS, including
 - Sound Projector Arrays (SPA systems)
 - Deployed on intakes / mobile systems for piling or blasting construction work
 - Deflects fish away from sound source
 - High Intensity Light Systems
 - Originally designed to deflect eels
 - Provides secondary stimulus for other fish species
 - SILAS (Synchronised Intense Light And Sound) Systems
 - Combines sound and light to provide two stimuli
 - BAFF (BioAcoustic Fish Fence)



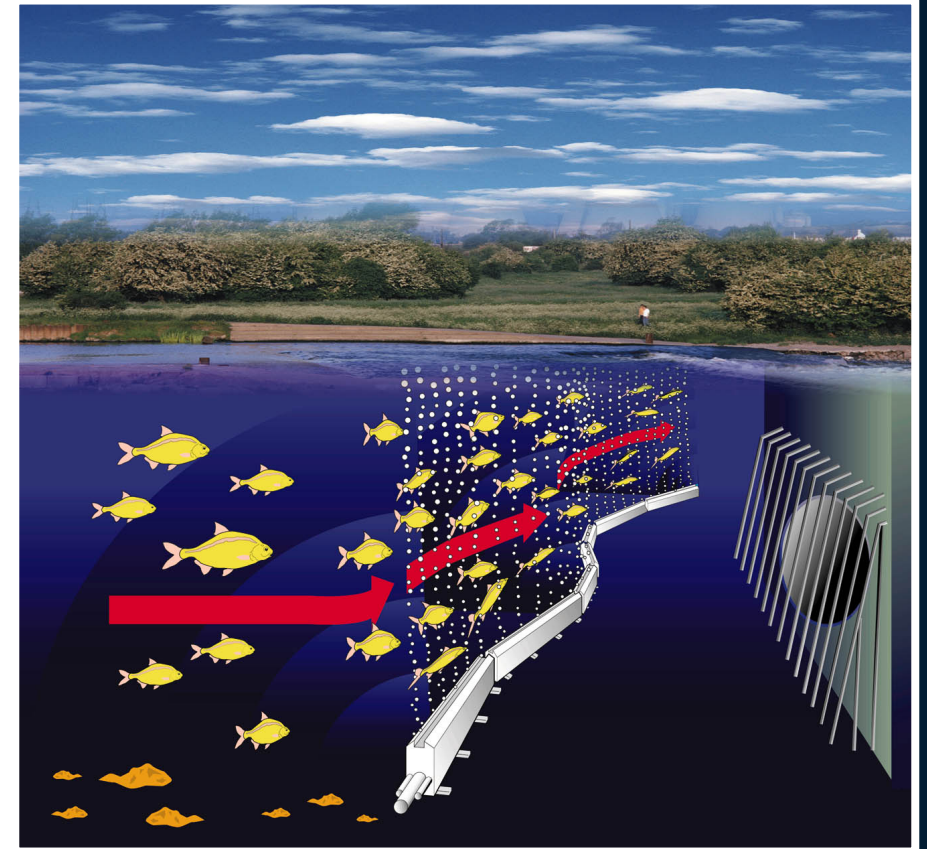
The Sound Projector Array (SPA)

- Analogous to an underwater Hi-Fi system
- Produces a repellent sound gradient in front of intake
- Used to block rather than guide fish
- Suitable for most intake types -
 - New
 - Retrofit on existing intakes
 - Freshwater and marine applications
- Mobile systems used for mitigation during construction work



The BAFF

- Combines an acoustic signal with a bubble curtain
- Creates a “Wall of Sound”
- Very rapid increase in sound level
- Signal can be focused on key species
- Enables fish to be guided out of a river / raceway
 - Deployed over last 20 yrs in UK in hydro-electric head races
 - Typically used to guide fish towards a fish pass / fish census
- More recently used for ‘blocking’ fish movement



BAFF Components

- Bankside Components

- **Control Equipment**

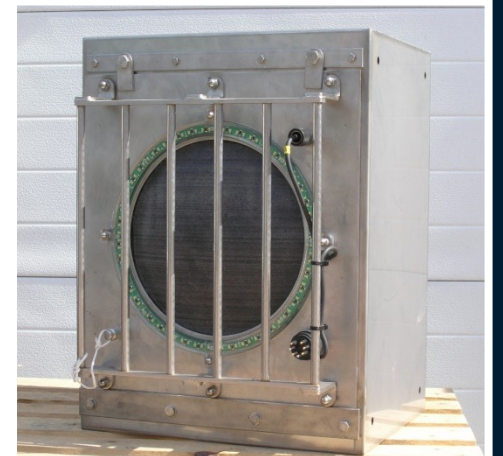
- SILAS Control Unit
- Power Supply/Control Units
- Internet Router / Firewall
- Auxiliary components - UPS / CCTV Control

- Deployed Components

- Power and Communication Hubs
- Sound Projectors / High Intensity Lights
- Bubble Pipes
- Power and Communication Cables
- Air Supply pipework
- Optional – Active Pressure Compensation System

- **Air Supply**

- Compressor
- Air drier
- Receiving Tank
- Manifold



System Performance

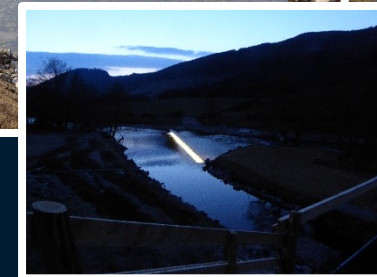
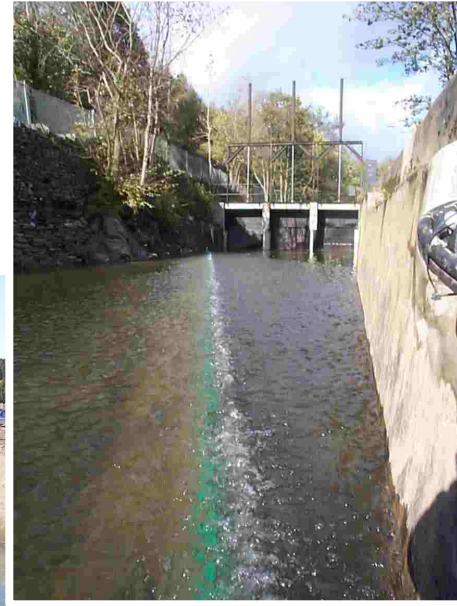
Are all the fish deflected?

- No behavioral system is 100% effective, but 100% deflection has been noted at some sites for particular fish species
- Under optimal conditions in excess of 90% deflection has been achieved
- This is exceptionally high for a behavioral barrier

Applications

- Migrating Salmonids
- Invasive Carp
- Clupeids
- General Fish Population

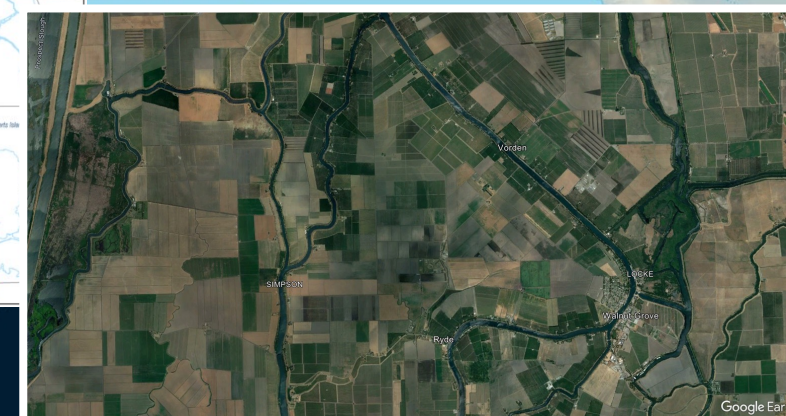
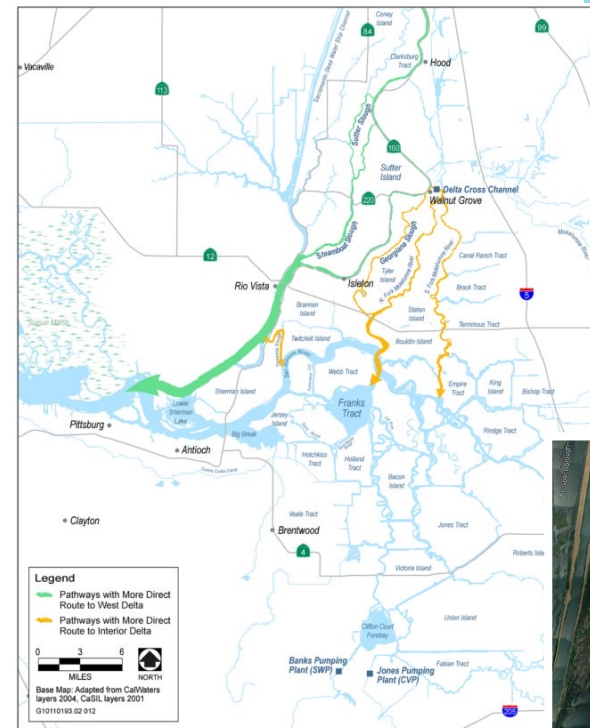
BAFF and Salmonids



BAFF and Salmonids - USA

California

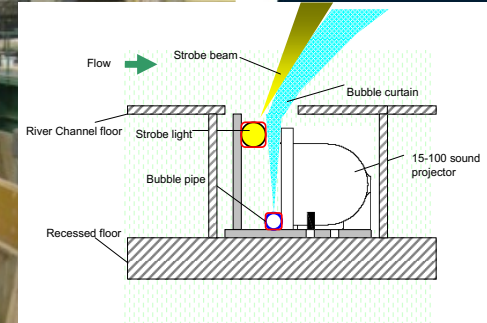
- 39 million people, 2.3m hectares of farmland
- State Water Project –
 - Diverts water from Sacramento-San Joaquin Delta to main urban areas (San Francisco and Southern California), as well as for irrigation
- 1992 Central Valley Project Improvement Act
 - Primary purpose – protect fish and wildlife
 - Main concern steelhead and Chinook salmon
- Modelling carried out by DWR indicated higher survival rate if smolt stay in Sacramento River at Georgiana Slough



Georgiana Slough

Laboratory Trials - 2009

- US Bureau of Reclamation (USBR), Denver
- Scale model created of initial test site – Head of Old River, San Joaquin River
- Small BAFF system recessed below base of channel
- Trial demonstrated up to 79.9% deflection efficiency
- Lead to deployment of BAFF system at Head of Old River 2010 and 2011 – 81.4% deflection



Georgiana Slough

2011-2012 Trials - Design

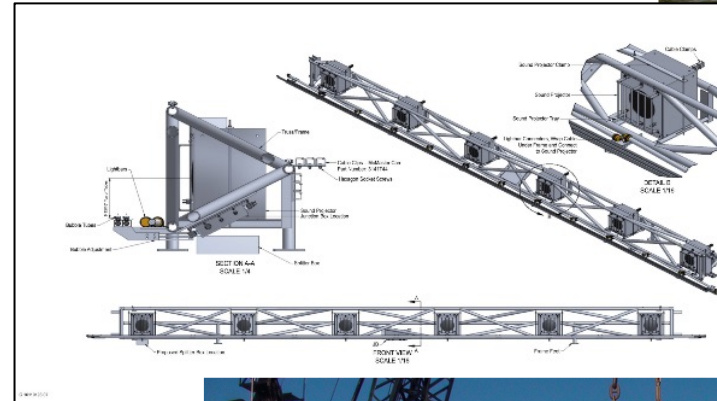
- Alignment of BAFF needed to allow for upstream flow during flood tides – carries smolt already past system back into Georgiana Slough
- Raise system from riverbed to enable sturgeon to swim underneath
- Minimum angle calculated as 24 degrees, based upon
 - Sustained swimming speed of 3.4 body lengths per second
 - 60mm length of Chinook salmon smolt
 - River velocity of 0.5m/s
- Maximum approach velocity 0.20 m/s



Georgiana Slough

2011-2012 Trials - System

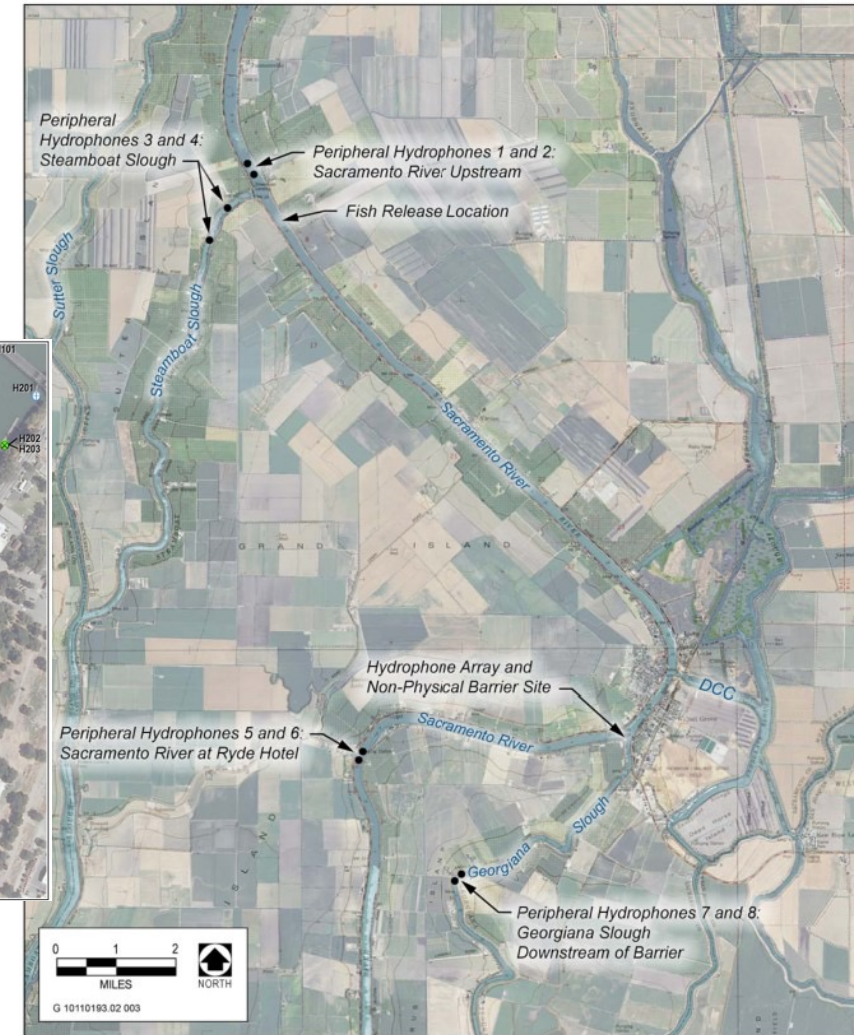
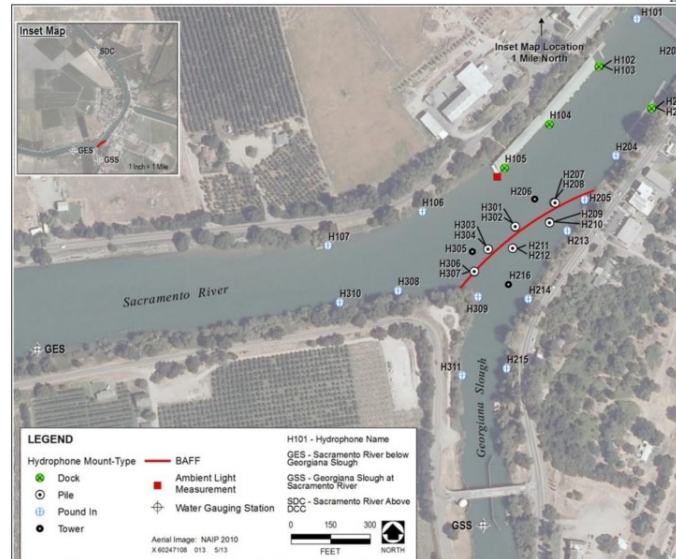
- BAFF 192m (630 ft) long
- SILAS system, with sound and lights
- Designed for easy deployment / retrieval
- Powered by generators
- Air supply via mobile compressors



Georgiana Slough

2011-2012 Trials - Evaluation

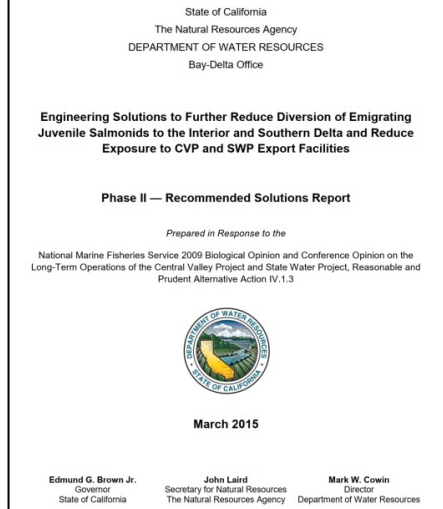
- USGS hydraulic modelling determined preferred location of BAFF
- Approx 1,500 Chinook salmon smolt
300 steelhead tagged each year
- Released 8.9km upstream
- Every 3 hours, for approx. 7 weeks
- Detailed 3D array of hydrophones around BAFF
- Assessed for DWR by HTI (now InnovaSea Systems Inc.)



Georgiana Slough

2011-2012 Trials - Results

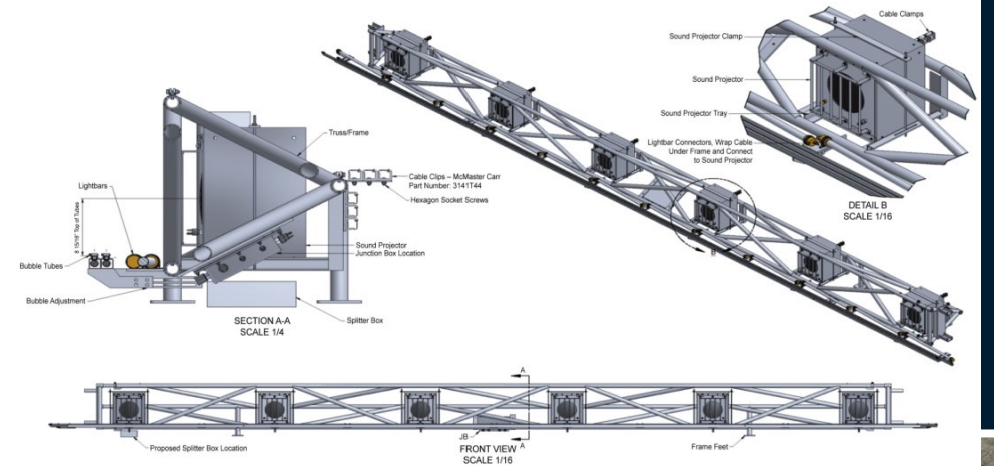
- System evaluated to determine overall efficiency
- Georgiana Slough **89.7%** entrainment reduction / onward passage of Chinook salmon smolt and **87.7%** for steelhead smolt
- Final Solutions Report recommended BAFF to be installed at four out of five sites across Southern Delta
- Since Final Solutions Report - 'permanent' system at Georgiana Slough instigated twice, but stopped due to funding decisions



Georgiana Slough

Permanent Installation

- 2020 California Department of Fish and Wildlife (CDWF) issued Incidental Take Permit as part of California's Water Plan
- BAFF required to be installed from 2023 through to 2030
- DWR requested upgraded BAFF in comparison to 2011-2012 trials
- Design for permanent system completed over 18 months, 2021-2022



2023 BAFF Design Requirements

New System Specification

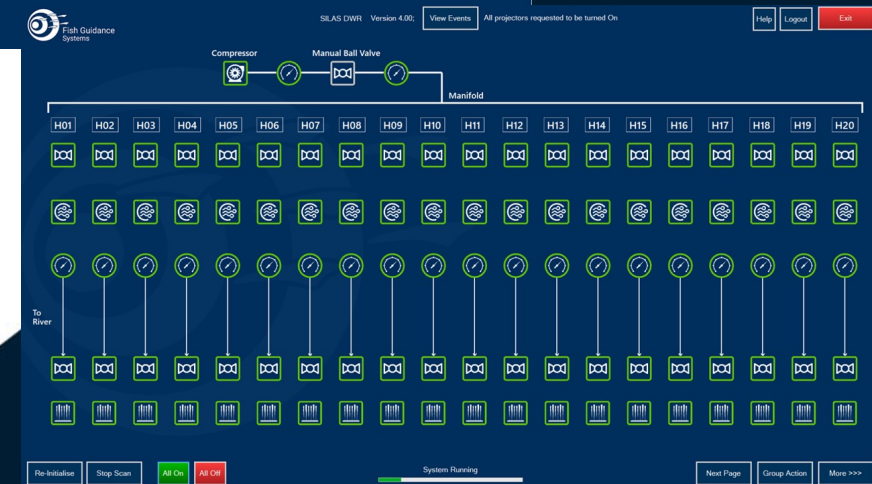
- Use existing sixteen 2012 Deployment Frames
- Use same MkIII version of Sound Projectors as 2011-12
- Upgrade to full automation – including air supply
 - New purge valves
 - Automated regulation of air supply via new manifold
- Enable remote operation – from operators offices / homes
- Provide additional redundancy - dual redundant Power and Communication Hubs
- Upgrade to include self-cleaning Light Bars



2023 BAFF Design Requirements

New System Specification

- Futureproof, with expandability in the future
- Removable in case of floods
- Enhance existing diagnostics and control
 - Increased number of components monitored across system
 - Introduction of electronic air supply manifold
 - Integration of air supply control – auto purging
 - Resulted in major upgrade of SILAS software
- Upgrade Graphical User Interface
 - Retain traffic light system
- System supplied 2022



Installation

Spring 2023

- Initial assembly and testing of Deployment Frames

BUT

- California experienced unusually heavy rainfall over 2022-23 winter
- Snow fall in mountains up to 60' deep (double the average)
- Flooding across the state
- River flows four times higher than safe for diving
- Installation postponed until autumn 2023



Operation - Optimisation

2023 - 2030

- October – June each year
- System to be removed for the summer months
 - Required as part of permitting (no power over summer)
 - Enables maintenance work
- System to be assessed for first two years
- Potential to optimise positioning of the BAFF
- Up to four additional Deployment Frames can be added to the system (192m to 240m / 630 feet to 787 feet)
- Planning for next site to start in 2024



Finally

- BAFF being used to deter upstream migration of invasive carp
- Trial based at Barkley Lock, Kentucky
- Being assessed by USFWS / USGS
- Final results available summer 2024

Thank you for you time.....

Questions?

