

Surface Water Diversions and Fish Protection

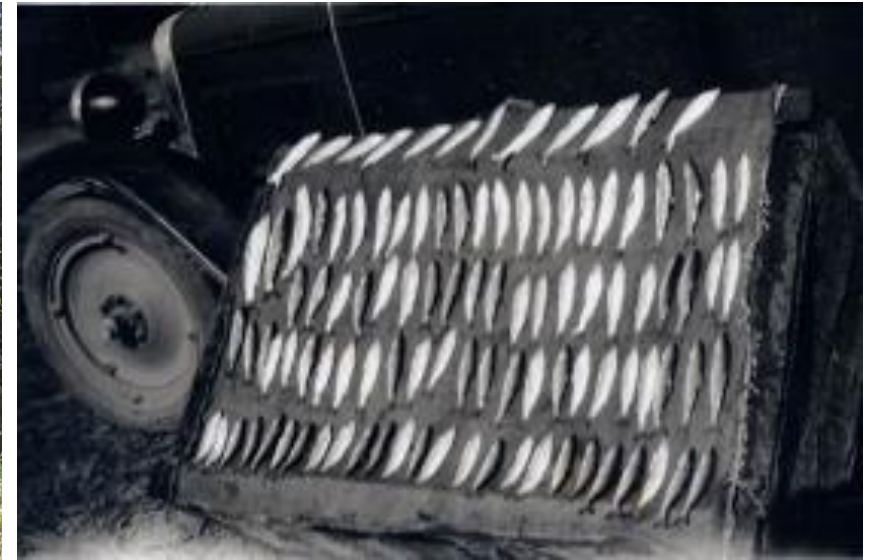
Presented by Shane Sheldon, PE

The Need

*Taking water out of its
natural location*

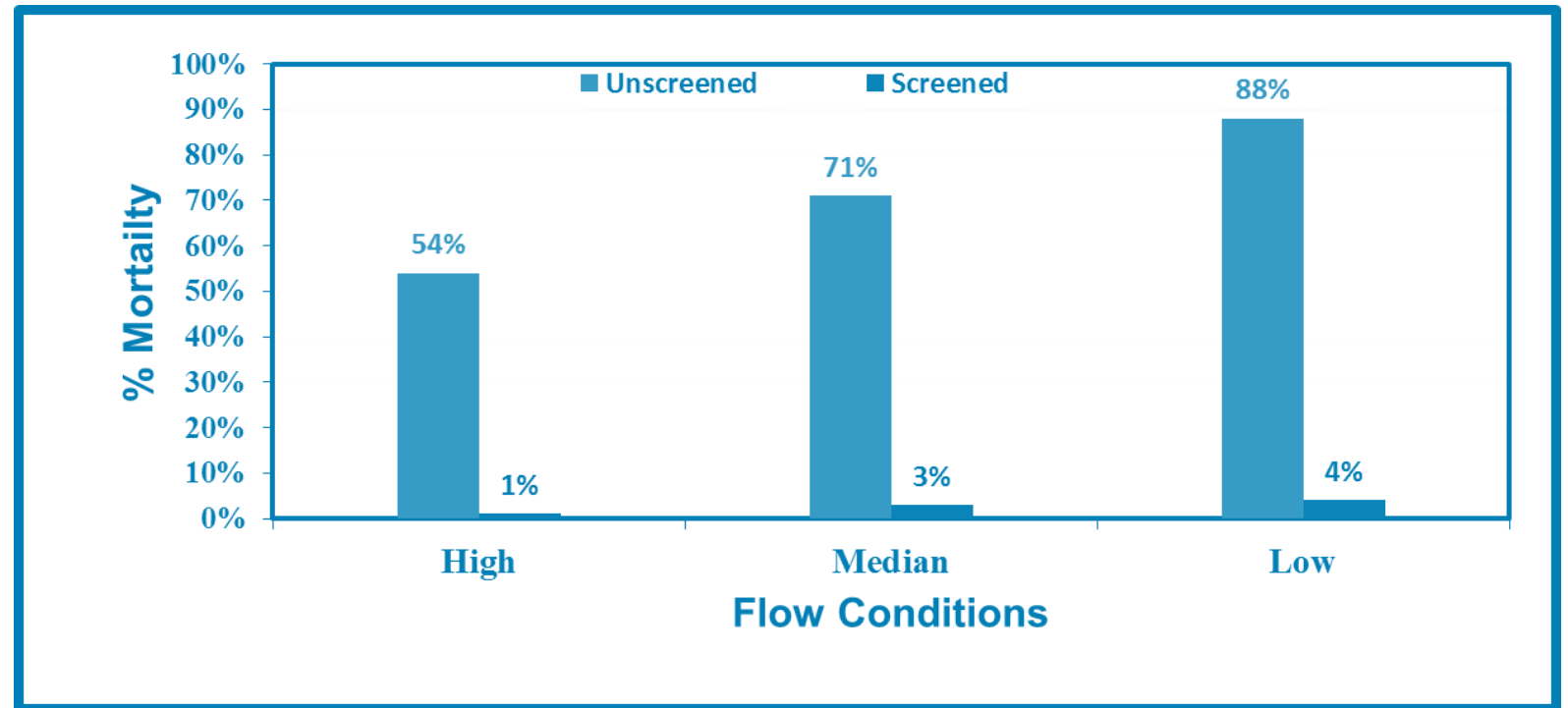


The Impact



The Impact

The cumulative effect of water diversion on smolt out-migration was substantial, the installation of fish screens would reduce entrainment by 50-90%



Annika W. Walters, Damon M. Holzer, James R. Faulkner, Charles D. Warren, Patrick D. Murphy & Michelle M. McClure (2012): **Quantifying Cumulative Entrainment Effects for Chinook Salmon in a Heavily Irrigated Watershed**, Transactions of the American Fisheries Society, 141:5, 1180-1190

The History

- 1946 - WDFW began providing screening services
- Endangered Species Act



The Challenge



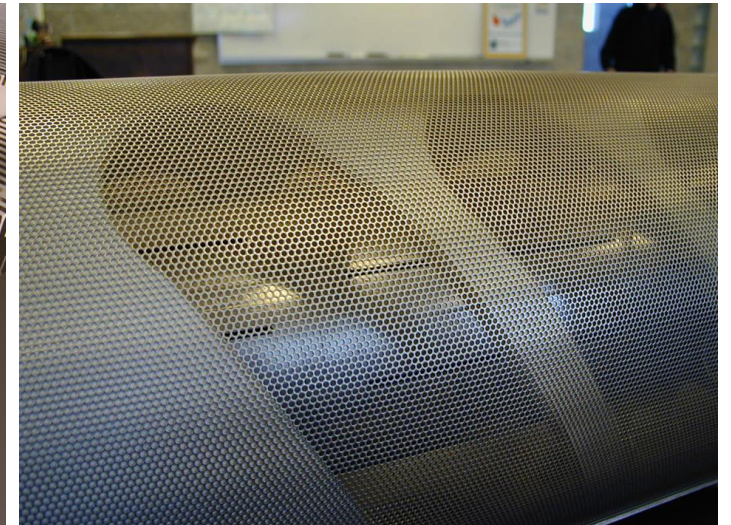
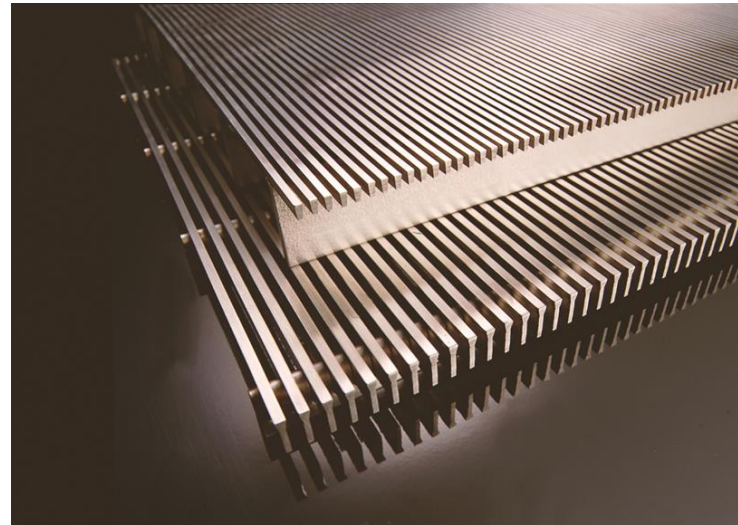
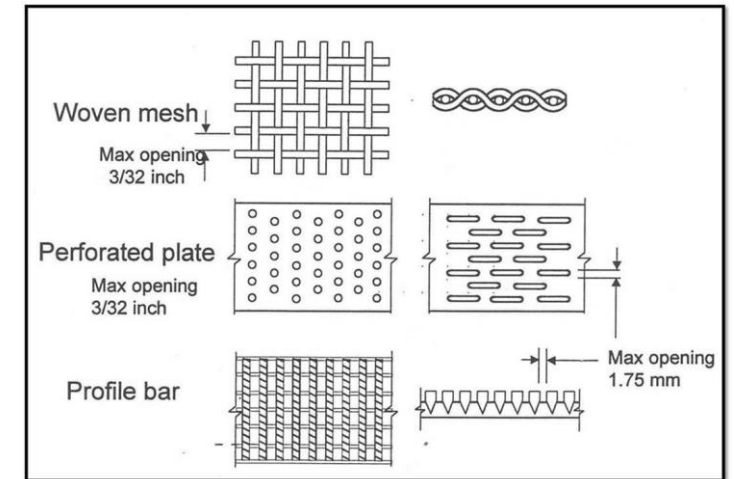
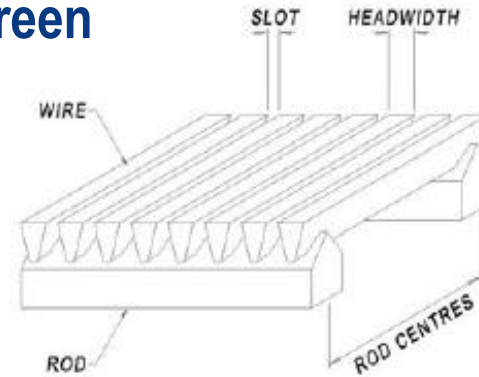
Screening Solutions

- **Biological basic for design criteria**
 - Swimming abilities
 - Size
- **NMFS keeper of the criteria and generally states follow**
- **Physical barriers are the standard over behavioral devices**
 - Lights
 - Sound
 - Electrical fields



Screen Material

- Welded screen (wedge wire)
- Profile bar screen



Screen Type



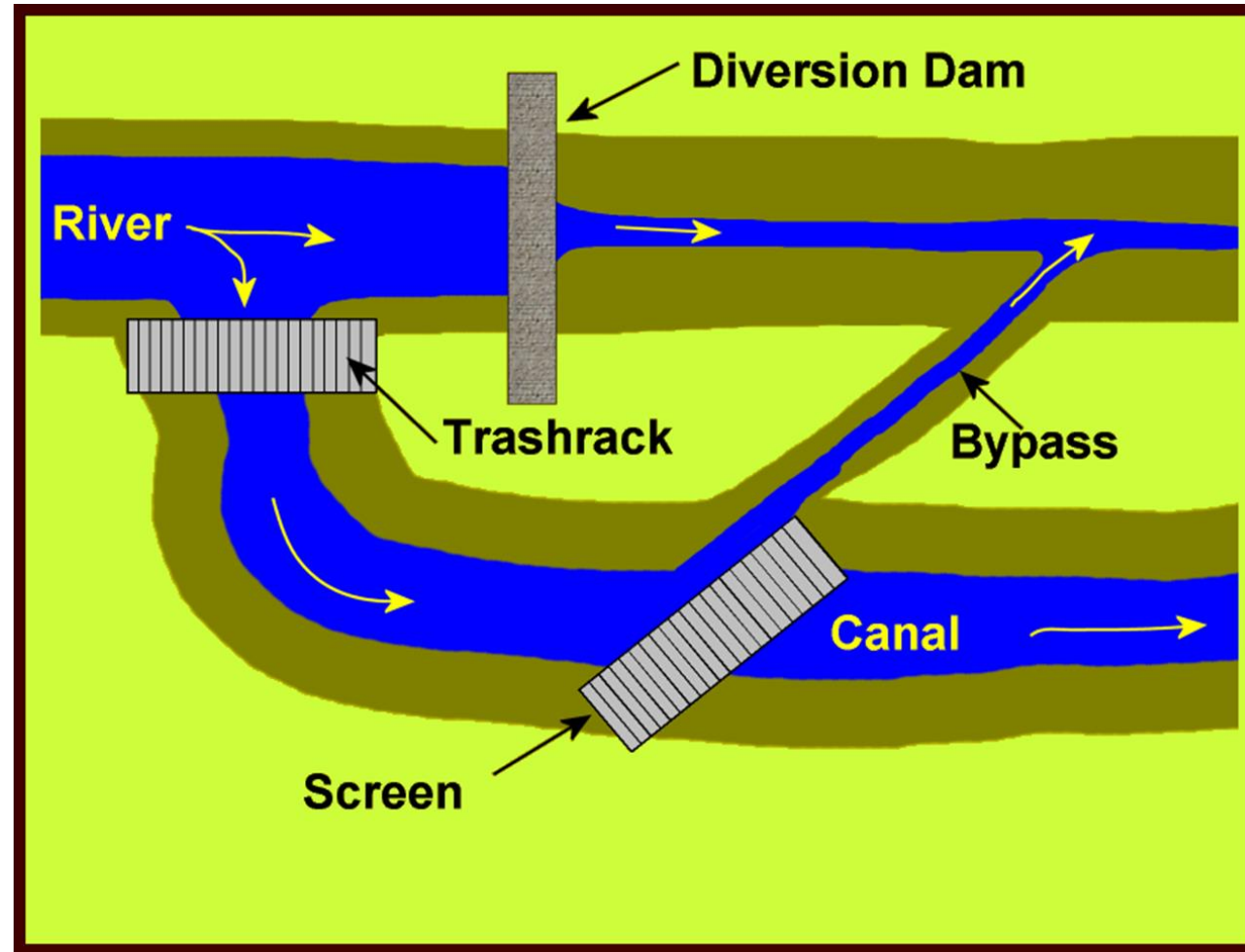
- In or on channel
- Downstream control
- No bypass



- Off channel
- Upstream control

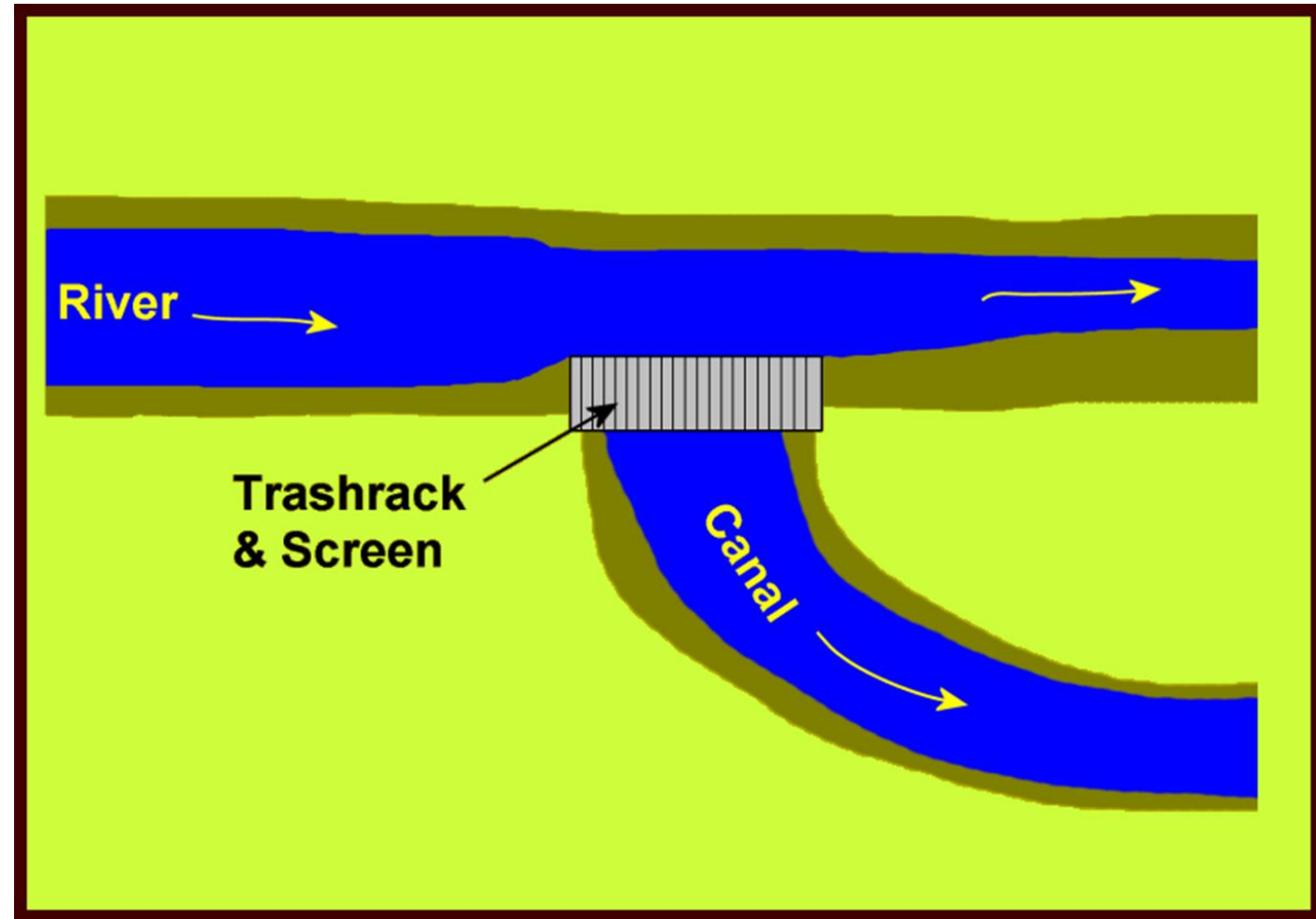
Diversion Type

Off Channel Screen



Diversion Type

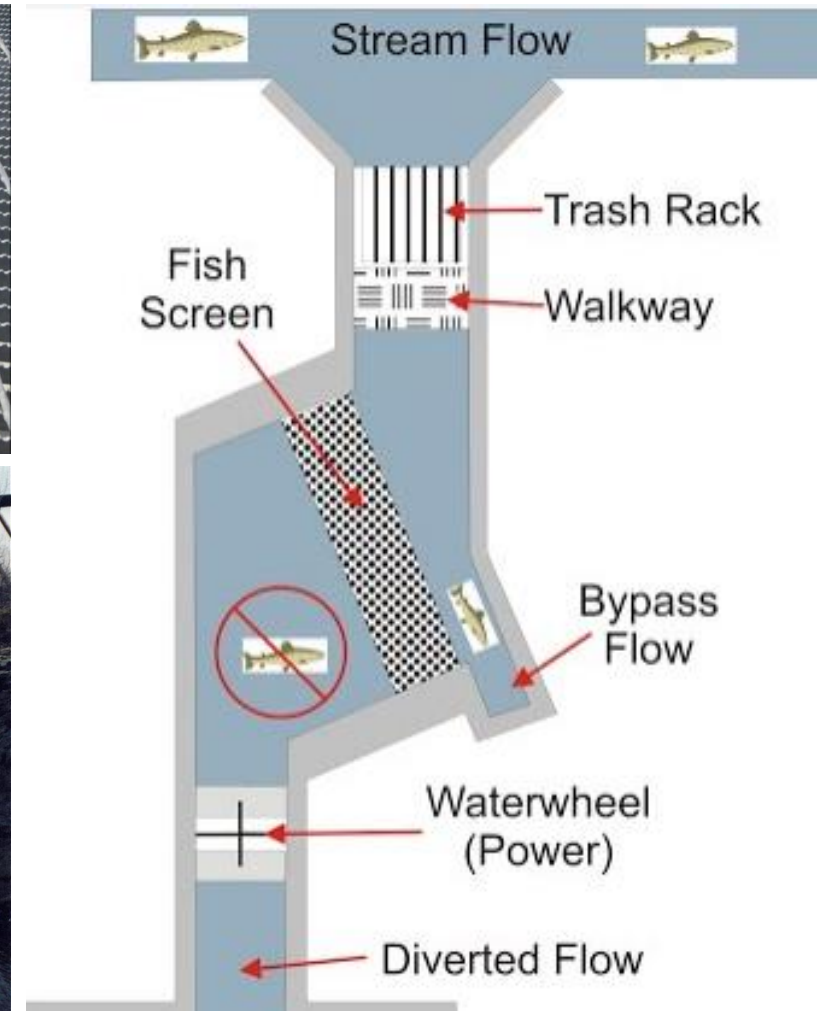
On Screen



Screen Types

- **Off Channel**
 - Rotating drum (conventional style)
 - Horizontal fixed plate
 - Eicher screen (inclined inside pipe screen)
- **On Channel**
 - End-of-pipe screens (cone, cylinder, etc.)
 - Tee-screen (fixed or rotating)
 - Floating surface collectors
- **Both (theoretically)**
 - Fixed vertical and non-vertical plate
 - Vertical or horizontal traveling – belt and panel
 - Coanda (weir screen)

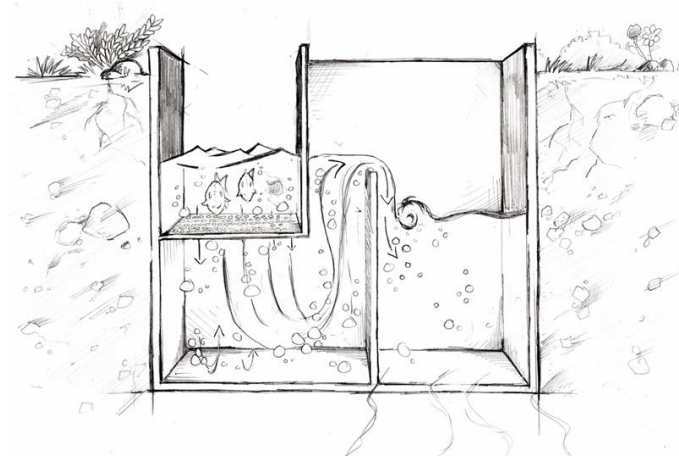
Rotary Drums



Rotary Drums

- Susceptible to direct hits from large debris
- Seals require much maintenance
- Susceptible to abrasions
- Passing debris downstream may require debris screens if using sprinklers or hydro turbines
- Requires careful attention to water depth
 - 65% to 85% submergence
 - May require checkboards downstream

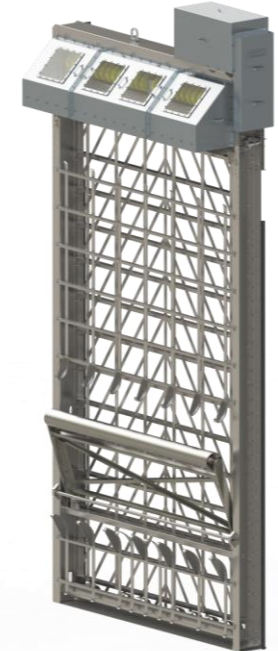
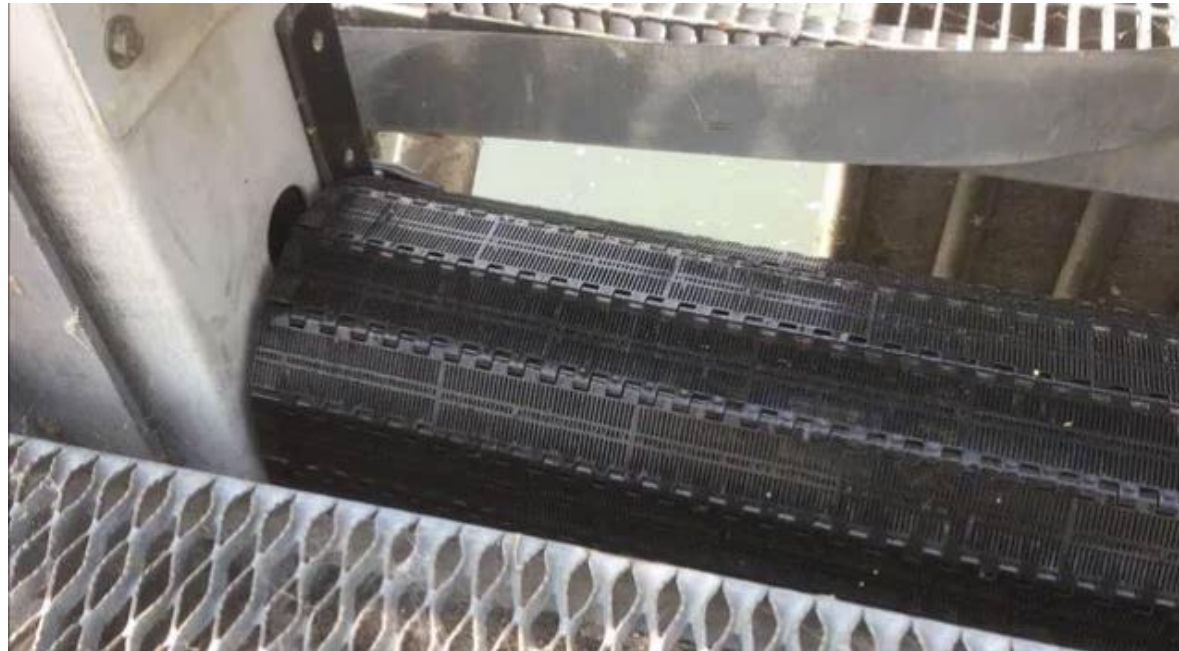
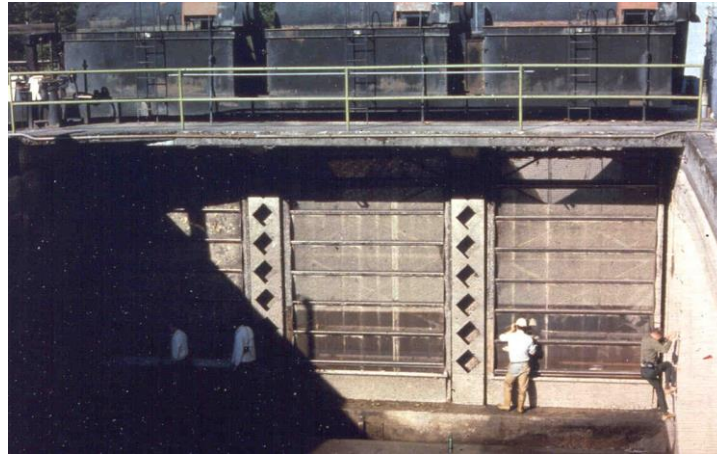
Horizontal/ Farmers Screen



Horizontal Plate Screen

- More headloss than other screen, requires higher gradient system (~2% stream slope min)
- Requires more bypass flow
- Large civil footprint
- Works well for:
 - High sediment systems
 - High organic debris systems
 - Remote sites with no power available

Vertical Traveling Screens



Vertical Traveling Screens

PROS

- Can be installed on channel
- Compact civil works
- Jet sprays provide additional cleaning.
- Possible to add trash conveyor behind screen to keep debris out of canal

CONS

- Mechanically complex
- Seals can be a problem
- Sediment can wear down belting
- In some cases, stretching has been an issue

End of Pipe

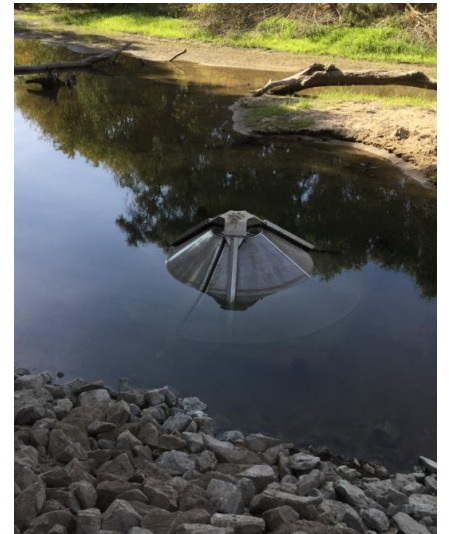
- Passive or active
- Often wedge wire
- Air burst, bushed, back spray



End of Pipe - Cylinder



End of Pipe - Cones



End of Pipe Advantages

- Good option for deep intakes
- Air burst cleaning system can be made to be effective
- Some have effective brush cleaners
- Some off-the-shelf models with water backwash systems meet NMFS criteria for active screens
- Some can be easily removed for off-season

End of Pipe Disadvantages

- Out of sight, out of mind (difficult maintenance)
- Need current to transport debris from screen site
- Air burst systems on large installations don't always clean entire screen - especially the bottom
- Long, stringy vegetation is a problem on small pump screens
- Requires sufficient depth to meet clearance criteria
 - $\frac{1}{2}$ screen diameter all around screen
 - Therefore, minimum water depth must be 2x screen diameter

Vertical Panel



Cleaning Systems



Vertical Fixed Plate Screens

- Mechanically simple and easy to seal
- Can be installed on channel
- Large bypass flows required if installed in canal
- Brush arms can be damaged by large debris
- Sediment accumulation can cause brush problems
- Very tall screens can have difficulty holding brush tight to screen
- Brush cleaners can be mechanically complex

Other Screens

- **Coanda screen**
- **Barrier**
 - Not NMFS approved
 - Eicher screen



Diversion Design

*Screen & intakes
work together*



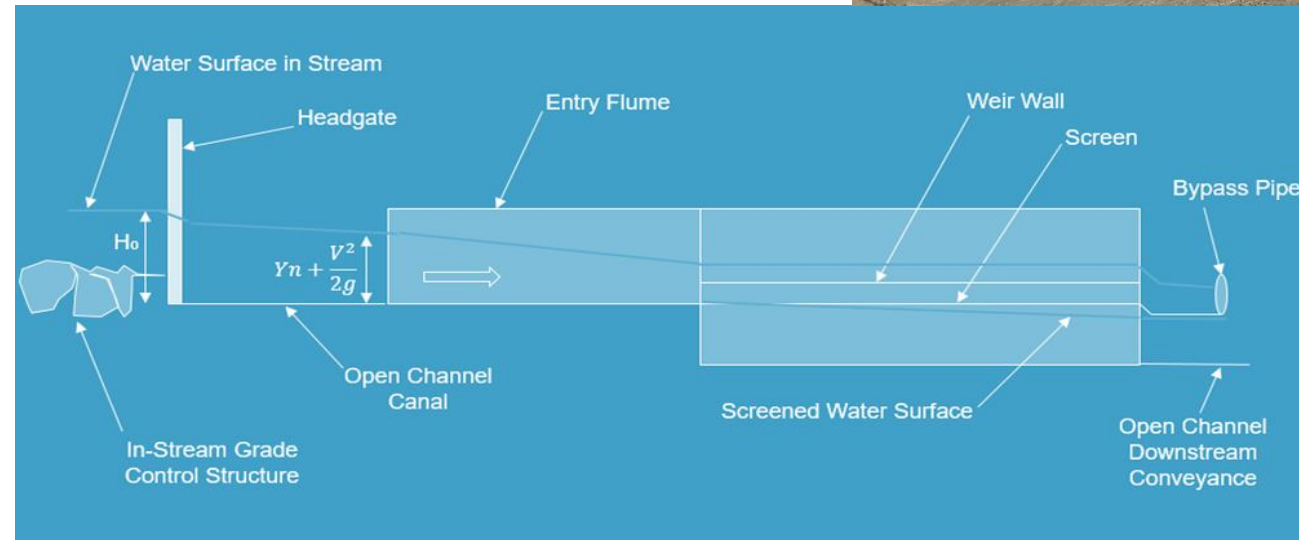
Intake Design

- **Materials can vary**
 - Place or precast concrete, metal, wood
- **Bedload sediment transport can often be mitigated by intake design**
 - Orientation to stream
 - What is the morphology of the stream



Intake Design

- Entrance hydraulics
- Headloss
- Water surface profile especially for gravity systems behind a headgate



Design Considerations - Trashracks

- **Trashracks have to be cleaned too!**
 - Sweeping flow
- **In some cases, on channel T-screens or cone screens should be equipped with trash racks deflectors**



Design Considerations - Sediment

- **Bedload vs. suspended**
- **Sediment sinks**



Entrance Conditions and Screen Orientation

- **Cascading screen clogging**
- **Avoid turbulence and hotspots**
- **On channel screens**
 - Deflectors
 - Screen orientation to flow



Design Considerations

- Bypass

- If off stream screen is used, a formal bypass is required
- Balance of preventing backwater and not injuring fish



Design Considerations - Flooding



Maintenance



- **Will it last?**

- Is screen shielded from debris?
- Is sediment management accounted for?
- Is there a maintenance plan in place for the system?
 - Who is responsible for maintenance?

Summary

- **Often complex projects with multiple stakeholders with conflicting interests**
 - Fish passage and protection
 - Operations
 - Cost
- **There are very effective solutions**
- **Can be a catalyst for more installation of more efficient infrastructure**
- **Consider long term maintenance**
- **Use your experience as a guide**



Questions



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From Screens to Irrigation Modernization

- Allowed District to pipe and pressurize 11 kilometers of open canal
- Allowed installation of 1 Megawatt of hydropower capacity
- Allowed individual users to install center pivots and micros
- District diverts 40% less water to irrigate the same number of acres
- Removed 147 pumps from their system



Modern Irrigation

- Farmers ID, OR
- Constructed 2003
- 80 CFS maximum
- 1 of 7 screens
- 4.8 Megawatts of hydropower production
- \$550,000 USD



Screen Project Benefits

- Saves \$90,000 USD per year in operational costs
- Increased hydro production by 23%
- Facilitated piping and pressurization of 64 kilometers of open ditches
- Allowed removal of over 1,400 pumps
- Facilitated on farm improvements



Farmers Screen

