Surface Flow Outlets (SFOs) for Passing Smolts at Columbia and Snake River Dams

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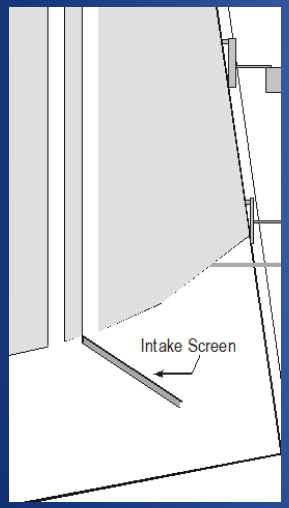
Smolt Protection Strategies

Turbine Intake Screens



Voluntary Spill

Photo by M Weiland

Surface Flow Outlets

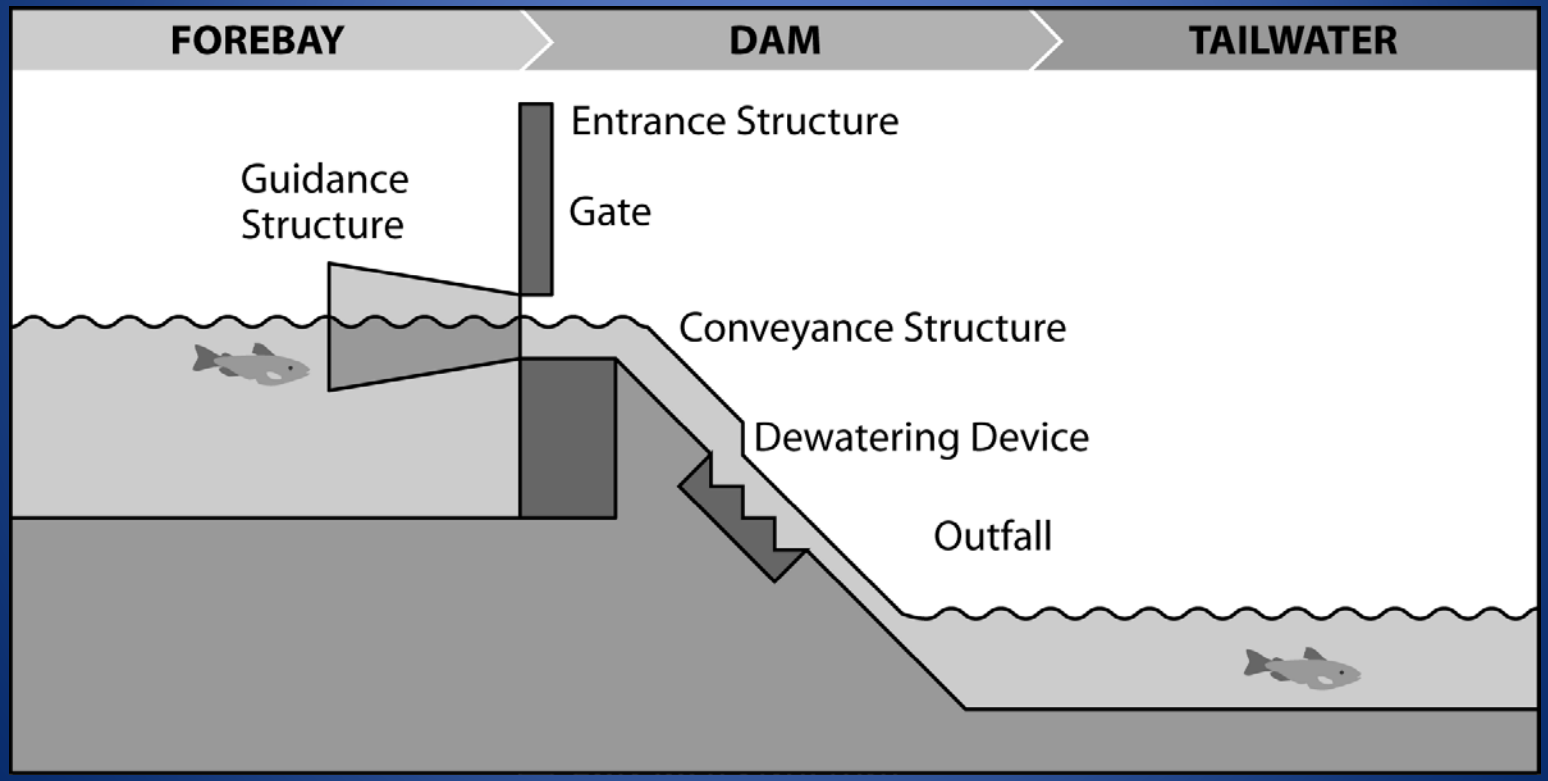
2014 BiOP p.188 “the essential feature of safe passage for ESA-listed outmigrating juvenile salmonids at FCRPS dams in the lower Snake and Columbia rivers has been improved by a number of structural improvements and operations …these include the construction and operation of surface bypass routes at all eight projects and new spill patterns to provide attraction flows to surface bypass weirs.”

Outline

- What is an SFO – components, spatial zones, premises?
- What types of SFOs are deployed?
- What were key steps in SFO evolution?
- Where and when were SFOs developed?
- What does development at a given dam involve?
- What are the demonstrated benefits of SFOs?

SFO Components

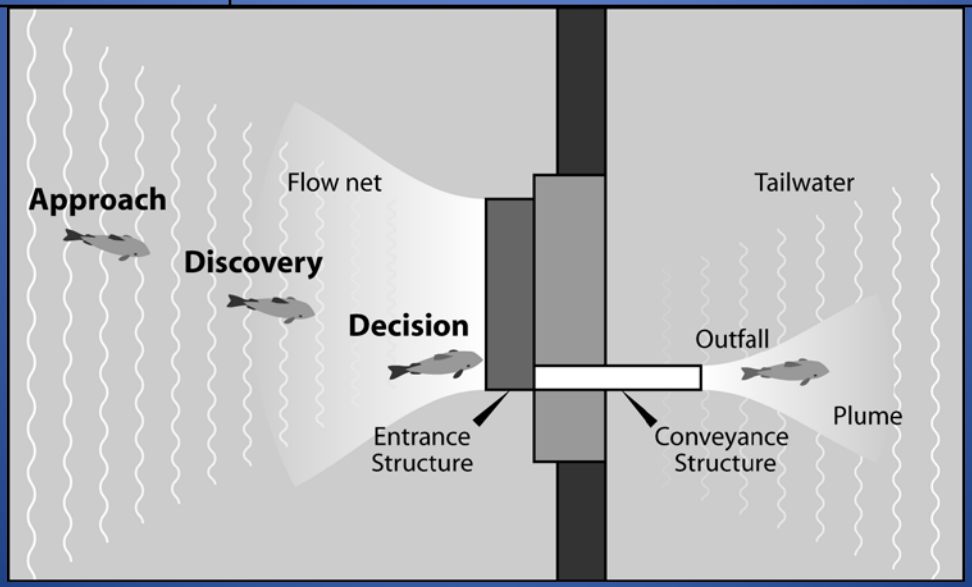
A SFO is a non-turbine passage route with an overflow structure through which flow and fish pass over a dam. SFOs have a large unobstructed intake(s) with high flow volumes, extend from the water's surface to various depths, and are strategically located where smolts congregate or in the migratory pathway.



(From Johnson and Dauble 2006)

SFO Spatial Zones

Zone	Distances from SFO	Principal Features
Approach	100-10,000 m	Channel depth, channel shape, discharge, current pattern
Discovery	10-100 m	Forebay bathymetry, structures, velocity gradients
Decision	1-10 m	Velocity, acceleration, strain, turbulence
Tailwater	0-1,000 m	Entry jet, ambient flow field, current patterns



(From Johnson and Dauble 2006)

SFO Premises

Zone	Premise
Approach	Smolts follow the bulk flow as they approach the dam.
Discovery	Smolt migration is active, not passive; Smolt vertical distribution is surface-oriented; Smolt horizontal distribution is concentrated upstream of the SFO.
Decision	SFO entrance conditions do not elicit an avoidance response.
Conveyance	Smolts stay in and pass through the conveyance structure safely.
Outfall	Smolts safely enter the tailrace and quickly migrate downstream.

SFO Types

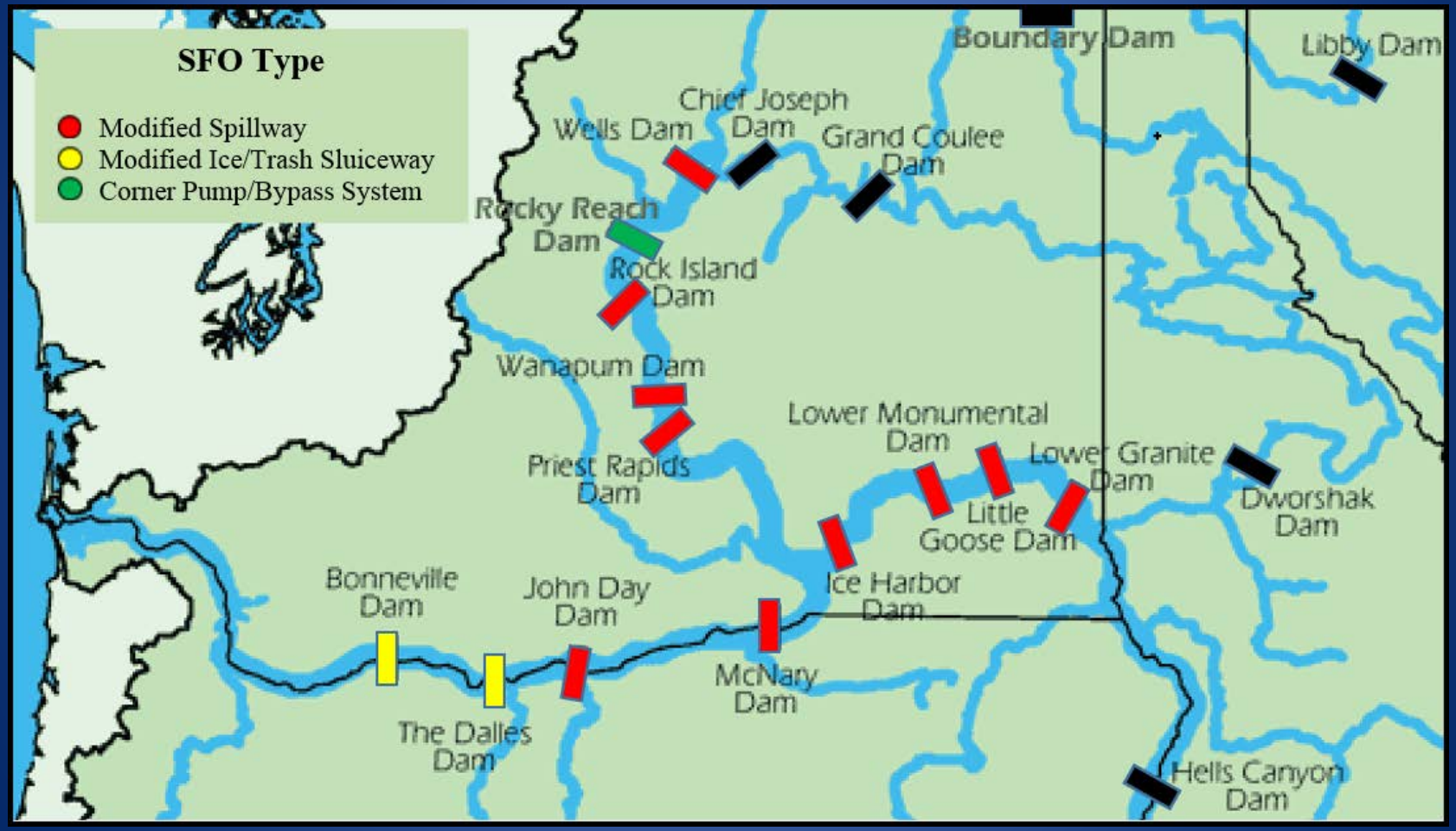
- Free-flow systems:
  - Spillway-based
    - weirs
    - new outlet or modified entrance configurations
    - ~10 kcfs/bay
  - Sluiceway-based
    - as built or modified
    - ~5 kcfs total
- Pumped system
  - Corner collector, dewatered
  - ~6 kcfs dewatered to 240 cfs

JDA
(M Weiland)

TDA

RRH

SFO Installations



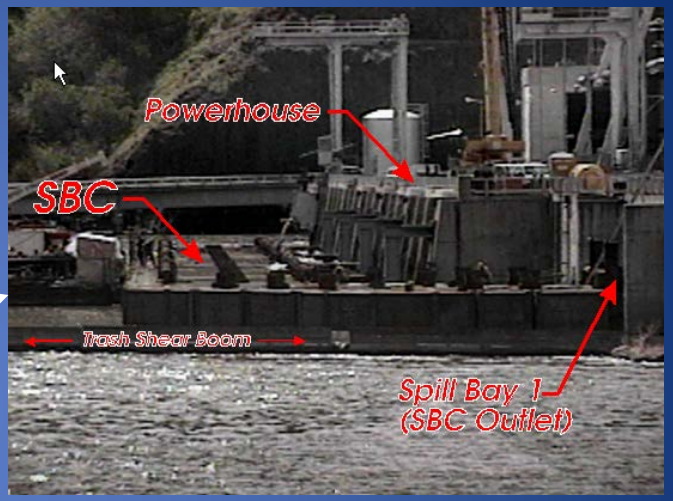
SFO Evolution

- As built structures = ice and trash sluiceways.
- Wells hydrocombine
- Corps Surface Bypass Program
- HCPs and BiOps and regionally-prescribed fish performance standards
- High flow outfall research
- Removable and temporary spillway weirs

Mike Erho

SFO Early Failed Prototypes (examples)

- Wanapum – Surface Attraction Channel
- Lower Granite – Surface Bypass and Collector
- Bonneville 1 – Prototype Surface Collector

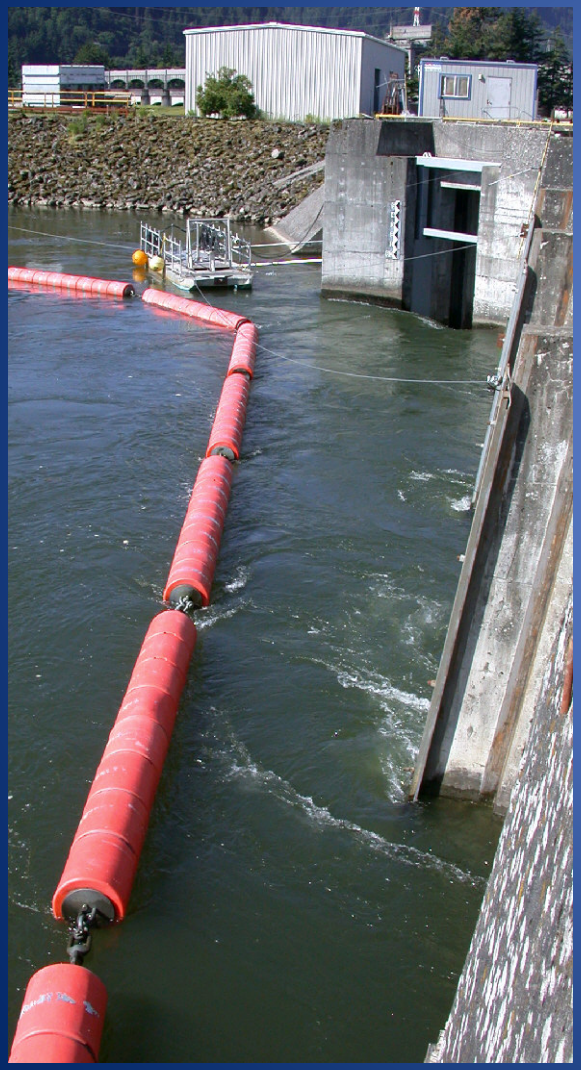


SFO Development by Dam

Dam	SFO Type	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
Wells	Modified spillway												X																						
Rocky Reach	Pump collector																						X												
Rock Island	Modified spillway																						X												
Wanapum	New outlet																											X							
Priest Rapids	Spill bay weir																																	X	
Lower Granite	Spill bay weir																				X														
Little Goose	Spill bay weir																												X						
Lower Monumental	Spill bay weir																											X							
Ice Harbor	Spill bay weir																								X										
McNary	Spill bay weir																										X								
John Day	Spill bay weir																											X							
The Dalles	Sluiceway -- as built																																		
Bonneville 1st	Sluiceway -- as built																																		
Bonneville 2nd	Sluiceway -- modifed																							X											

Legend:
R&D+Construction
Installed SFO

SFO Site-Specific Development



- Rigorous design process by a team of engineers and biologists
- Alternatives studies
  - Determine SFO encounter potential via field studies
  - Hydraulic modeling forebay & tailrace, entrance and egress
  - Criteria to compare and contrast alternatives
- Prototype tests
- Final design and construction
- Evaluation and tailoring routine operations

SFO Benefits

- High smolt survival rates
  - 99.28% (SE 0.02) B2 corner collector, 2011, CH1
- Short smolt forebay residence times
  - Mean 1.22 h (SE 0.08) TDA, 2011, STH
- High proportion of smolts in a small amount of water relative to other routes
  - %SFO fish:%SFO flow = 15, Wells, run-at-large
- Safe route for downstream passage for *adult* salmonids
  - 93.6% (SE 0.02) Little Goose RSW, 2013, STH kelt

SFO Possible Future Operations

2014 BiOp, p.381 “There is evidence that conventional and surface spill pass a greater proportion of fish for a fixed spill percentage at lower flows than at higher flows (NOAA Fisheries unpublished analyses). Thus, high spill percentages may not be needed to pass the same proportion of fish in lower flow years.”

SFO References

- Skalski et al. 1996. Statistical evaluation of turbine bypass efficiency at Wells Dam on the Columbia River, Washington. CJFAS 53:2188–2198.
- Giorgi et al. 2000. Critical assessment of surface flow bypass development in the Lower Columbia and Snake rivers during 1995-1996, pp. 41–55. In: Advances in Fish Passage Technology.
- Johnson and Dauble. 2006. Surface flow outlets to protect juvenile salmonids passing through hydropower dams. Rev. Fish. Sci. 14:213–244.
- Sweeney et al. 2007. Surface Bypass Program Comprehensive Review Report (the “Compendium”). Technical report submitted to CENWP.

Thank You