Opening the Gates: Solutions for Fish Passage and Flood Control
Virtual Knowledge Exchange Workshop | *September 10, 2025*

Introductions and Welcome

Moderator Laura Weatherly (DFO) welcomed participants and outlined the workshop theme, objectives and context, noting:

- Workshop is co-hosted by Fisheries and Oceans Canada, Pacific Salmon Foundation and the Washington Governor's Salmon Recovery Office.
- Nearly 1,000 virtual participants attending. Majority are from BC and Washington, with strong representation from Oregon, California, Idaho, and provinces like New Brunswick and Nova Scotia. International representation as well (Mexico, Punjab, Guyana and New Zealand).
- More than 50% of attendees are affiliated with government (civil, provincial, federal, state, county). Nearly 20% are consultants and private industry.
- This is the 9th workshop in the Knowledge Exchange series; the 10th workshop on floodplain restoration is planned for November. The PSF website includes a full library of recordings, reports and resources from the workshop series.
- Jason Hwang can't attend. Greer Maier, Washington, is welcomed as co-moderator and added welcoming remarks.

Tide gates and floodgates: All you wanted to know but never dared to ask

Guillermo Giannico, Oregon State University

- **Definition and Operation**
  - Tidegates and flood gates act like doors, regulating flow between freshwater and estuarine or river environments.
  - Typically paired with culverts (pipes or concrete boxes) under roads or dikes.
  - Open and close with tidal cycles and upstream water pressure.
- **Types of Gates**
  - **Top-hinge gates**: common, effective at flood control but restrict fish passage; flows are fast and turbulent when open.
  - **Side-hinge gates**: stay open longer with slower, more laminar flow; provide somewhat better passage conditions.
  - **Float-mediated and other designs**: newer attempts to balance flood protection with fish passage.
- **Geomorphic and Habitat Effects**
  - Cause scouring both upstream (pools) and downstream (erosion from concentrated flows).
  - Create artificial impoundments upstream; stagnant, warm water leads to poor water quality.

  - Alter sediment transport, vegetation (shift from estuarine to freshwater species), and fish community composition.
- **Key Impacts on Fish and Aquatic Communities**
  - Physical barrier to migration (especially upstream).
  - Altered water quality: changes in salinity, temperature, dissolved oxygen.
  - Disrupted estuarine transition for salmonids (stressful shifts from fresh to saltwater).
  - Favor invasive/warm-water species under gated conditions.
  - Increased disease risk due to bacterial changes.
- **Research Findings (Case Studies: Palouse & Larsen Creeks, OR)**
  - Non-gated streams: salmon smolts show repeated upstream/downstream movements, using estuarine transition zones.
  - Gated streams:
    - Downstream passage occurs but often delayed or forced in stressful flushes.
    - Upstream passage is rare (≈4% of smolts).
    - Migration timing and diel patterns altered (fish movements shifted from dawn/dusk to mid-day).
  - Gate angle critical: side-hinge gates open wider (~70°) than top-hinge (~30–40°), allowing more passage.
  - “Leaky” gates unintentionally improve connectivity by allowing limited brackish exchange.
- **Management Implications**
  - Fish passage improvement is a primary driver for gate replacement in the Pacific Northwest, often paired with flood control or infrastructure upgrades.
  - Designing for water velocity standards (<2 ft/s for juveniles; <4 ft/s for adults) remains challenging.
  - Gate retrofits/replacements can improve connectivity but rarely fully replicate natural conditions.

Questions

Do gates facilitate predation on juvenile salmon through acting as a barrier to movement - salmon fry buffet up against the gate (Morgan Edwards)?

- Yes. Observations from studies found when fish were delayed in their migration or patterns of movement, they would hang out around the culvert for shade and birds would arrive. Cormorants and egrets were common and they found fish tags in their waste. Cutthroat trout are also common predators in estuaries.

How can existing gates be retrofitted or engineered to improve fish passage while still providing flood protection?

- Engineering aspects are beyond speaker expertise.
- No 2 tide gates are the same. Site specific conditions should dictate unique design.

- One important finding was connectivity is important, leakage between the estuary and freshwater environments. It provides a cue for fish to adjust their migration. Bigger fish seem more ready to move.
- We also learned that cover is important, either artificial or natural

Where do you see the greatest opportunities for advancement on this topic – monitoring, engineering and innovation, understanding fish behaviour?

- All of the above.
- Better design standards.
- Differences in water chemistry can be an invisible barrier to fish.
- Monitor the most promising designs. Need more funding.

Oregon's tide gate journey: New solutions for tide gates, fish passage and working landscapes

Jason Nuckols, The Nature Conservancy

Highlights of this presentation included (See PowerPoint for details):

Historical Context

- Tide gates installed since late 1800s; expanded mid-20th century.
- Most gates now >70 years old; outdated and ecologically limiting.
- Originally designed for drainage, not fish passage or habitat function.

Early Replacement & Partnerships

- Conservation-based replacements began in early 2000s.
- Oregon Tide Gate Partnership formed to tackle design, permitting, and funding.
- Resources available via Oregon Watershed Enhancement Board.

Inventory & Data Collection

- Coastwide inventory identified >700 primary gates.
- Data housed on Oregon Explorer; ~90% gates privately owned.
- Funding challenges due to private ownership.

Funding Sources

- Support from NOAA, OWEB, ODFW, USFWS, and Business Oregon.
- Infrastructure upgrades tied to ecological benefits.

Permitting Challenges

- Complex, multi-agency process; often >12 permits per project.
- Partnership created guidance tools and process maps.
- NOAA's Programmatic Consultation streamlined reviews.

Project Implementation

- Example: $1M upgrade reopened 200 acres with muted tidal regulator.
- Prioritization essential—funding can't cover all gates.

Optimization Tool

- Adapted OptiPass model for tidal systems.
- Considers stream networks, tidal flows, budgets, and climate scenarios.
- Outputs: ROI curves, barrier tables, GIS maps.
- Example: $10M in Coos/Coquille could open >70 stream miles.

Scale of Impacts

- Columbia Basin: >75,000 acres behind gates.
- Coastwide: 1,100 miles of salmon streams, 22,000 estuary acres, 20,000 farmland acres, 1,000 buildings affected.

Monitoring & Adaptive Management

- New tiered protocols:
  - Tier 1: small/simple (implementation).
  - Tier 2: all projects (implementation + compliance).
  - Tier 3: large/complex (effectiveness).
- Data stored in ODFW's NRIM system.

Agricultural & Landowner Considerations

- Agriculture central to coastal economy.
- Study explored tide gate impacts on private landowners.
- Future work: site-specific cost-benefit analyses (e.g., forage, livestock, water management).

Questions

How do you respond to entities that criticize the practice of tide gate upgrades, since a barrier is still a barrier?

- Baseball analogy: upgraded tide gate is a "double" and tide gate removal is a "home run".
- We have to work within our land ownership context. 90% of gates are privately held. 50% of estuaries in Oregon are in private ownership. If we want to improve conditions on private lands, we have to consider the land use behind them (roads, railroads, towns).
- Investment is paying off since we can't go back 200 yrs.

What advice do you have for an entity or an organization that doesn't have the resources to do the extensive effort that you've done in Oregon? How should they approach this problem of prioritizing and identifying tide gates across a large area?

- The optimization tools we've developed can be used elsewhere.

Who do you see using your information? At what scale?

- Funding agencies are wanting to see where a proposed project falls in the model, what the targets are and where the best areas are to put limited funds on the landscape.
- Granting purposes to run different scenarios, Watershed Councils.
- The tool is meant to be a conversation starter, for example with a landowner, to show the effect of water management scenarios on the landscape and their farm.
- Wild Salmon Center uses it too.

Oregon now has a process of developing guidance and getting partners around the table. You're at the implementation stage now. What do you see as the key challenges to achieving agreement around the table on improving fish passage, and what are the strategies that you've come up with for overcoming these?

- We need to keep this discussion going with our legislation, with our funding agencies, and with those persons doing implementation on the ground. It starts with the conversations and we have to continue to keep this momentum going.
- There's probably many private landowners that have never heard of this. We have to promote our results and spend money on monitoring.
- Also need to consider adaptive management of the gates. After installation, there is work to be done with be sure the gates are working.

Break Slideshow

See workshop resources page for slideshow featuring a range of restoration project examples.

Fixing Fraser floodgates for fish

Dan Straker, Resilient Waters

Highlights of this presentation included (See PowerPoint for details):

- Focus on the **Lower Fraser watershed** in Canada (Lower Mainland, Metro Vancouver, Fraser Valley). **Resilient Waters project** began with Watershed Watch Salmon Society work in **2016**, ramping up in **2018** to map aging infrastructure.
- Initial mapping found:
    - 160 flood gates
    - 60 pump stations
    - 250 km of dikes
    - Blocking **1,500 km of off-channel and stream habitat**

Regional Context

- Fraser River estuary: nursery for one of the largest, most diverse salmon populations globally.
- Other pressures: 4th largest port in North America, 12th fastest-growing region in North America, highly productive agricultural land

- 31 First Nations, 25 local governments, ~3 million people (~half of BC population)
- Climate change impacts: atmospheric rivers, winter storms, sea level rise, summer droughts
- **Flood infrastructure replacement cost**: estimated **$8–$10 billion** vs. national fund of $3.5B.

 Historical Context

- Flood infrastructure in Lower Mainland built from **1800s onward**, often post-First Nations displacement. Approx. **90% of reserve lands** placed along rivers/coasts and prone to flooding.
- Existing infrastructure impacts salmon habitat and First Nations access and land loss

 Project Approach & Early Work

- Began in **2020** with outreach to **First Nations, local governments, experts**.
- **26 high-priority sites** identified for restoration or upgrade (flood gates, pump stations, dikes).
- Collaborative research with **Mike Pearson / Pearson Ecological**:
- Assessed fish composition, water quality, invasive species
- Data publicly accessible online
- **Genetic analysis**: mapped juvenile Chinook and coho origins using priority sites.

 Key Restoration Example – Joe's Lake Floodgate Replacement

- **Location**: Nicomen Slough, Fraser Valley
- Previous infrastructure: top-mounted flood gate, poor fish passage, blocked floodplain
- New solution: **vertically oriented flood gate, d**efault open 90% of the year and only closes during flood risk, reconnected floodplain, improved salmon access
- **Project details**:
- Duration: ~4 years from funding to completion
- Cost: ~$1M CAD
- Habitat opened: 5 hectares of high-value salmon habitat
- Funded by BC Salmon Restoration Innovation Fund, Pacific Salmon Foundation, Bonneville Environmental Trust

 Floodgate Design Considerations

- **Non-tidal vs. tidal scenarios**:
    - Non-tidal simpler, river-based flood risk
    - Tidal: complex, requires **self-regulating flood gates**
- Self-regulating gates typically top-hinge or side-hinge, triggered by floats (no power) or sensors
- Only 2 self-regulating gates in Lower Mainland:

- Defunct: Musqueam Creek
- Functional: Golden Harvest gate at Colony Farm (since 2010)

 Lessons Learned & Challenges

- Need willing local government and First Nation partners
- Solutions must: Improve fish habitat, reduce flood risk, possibly deliver other co-benefits
- Funding is competitive; multi-benefit projects harder to prioritize
- Regulatory guidance is limited, enforcement inconsistent
- Best practices not standardized, limited education in multi-disciplinary approaches
- Maintenance and monitoring essential: debris, beavers, operational oversight

 Additional Work & Outreach

- **Pump station study** with UBC Pacific Salmon Lab
- **Webinar series** on integrated floodplain management, bank stabilization, etc.
- **Lower Fraser Floodplains Coalition**: Collaborative group of First Nations, local governments, other sectors,

Questions

For your case study, how did you go from defining the problem to implementation in terms of the design and and piecing it together?

- Starting point is relationship with the First Nations. Also find local experts (in our case study, Pearson Ecological and KWL Engineering Consultants).
- Budget, then find funding options, and keep pushing the need at the political level.

Note from moderator that PSF Knowledge Exchange website has past presentation recordings, including one from Mike Pearson on monitoring tools.

Where do you turn for funding to do all of the monitoring and maintenance sort of work that has to happen in the in the lifetime of these projects?

- Need to be creative. DFO’s Salmon Habitat Innovation Fund has been a main source.
- Washington’s Floodplains By Design is a great model that we are trying to copy with the Lower Fraser Floodplains Coalition.

Fish in the floodplain: Self-regulating floodgates to improve juvenile salmon access to critical overwintering habitat

Zachary Sherker, The University of British Columbia and Oregon State University

Opening the Gates: Solutions for Fish Passage and Flood Control

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Highlights of this presentation included (See PowerPoint for details):

Context

- Flood gates act as barriers to fish; come in various designs (top-mounted, side-mounted, self-regulating).
- Lower Fraser River:
    - Over 185 known flood gates.
    - Only two self-regulating gates currently allow some fish passage.
    - ~95% of historical floodplain habitat inaccessible to juvenile salmon.
- Importance of floodplain habitat:
    - Juvenile coho and Chinook use floodplains to overwinter (Nov–spring).
    - Growth in floodplain habitats roughly double that in main stem.
    - Main stem overwintering is harsh: low prey availability, cold, high flows.
    - Gated sites have fewer native fish and more invasive species due to habitat disconnection.

Flood Gate Challenges

- Many structures built 70–100 years ago, not designed for extreme events (e.g., atmospheric rivers, large rainfall).
- Top-mounted and traditional gates severely limit fish passage and reduce floodplain habitat usage.
- Upgrading or replacing structures:
    - Self-regulating gates: designed to stay open unless flood risk occurs.

Study Design

- Compared three sites:
    1. **Top-mounted gate** (historic, ~80–90 years old)
    2. **Self-regulating gate** (installed 2012)
    3. **Ungated site** (decommissioned gate, fully open)
- Methods:
    - Released 1,500 PIT-tagged juvenile coho in batches of 50/week for 10 weeks.
    - Monitored attraction, upstream passage success, overwinter survival, and duration of residency.
    - Used paired PIT antenna arrays (12 total) for >90% detection efficiency, >800,000 detections, ~9,000 passage attempts.

Key Findings: Fish Passage

- **Approach success:**
    - Top-mounted: <30% of fish approached the gate.
    - Self-regulating: 65% approached.

  - Ungated: 70% approached.
- **Passage success (for fish that approached):**
  - Top-mounted: <30% successful.
  - Self-regulating: ~62% successful.
  - Ungated: ~80% successful.
- **Time to pass:**
  - Top-mounted: 45 minutes on average (7m culvert).
  - Self-regulating & ungated: ~35 minutes.

Tide Influence

- Passage strongly tied to tide height:
  - Most fish approached between 1.5–2.0 m tide height.
  - Self-regulating gates often closed before peak approach, indicating potential to improve timing to increase passage success.

Floodplain Residency & Survival

- **Duration upstream:**
  - Top-mounted: ~30 days.
  - Self-regulating: ~65 days.
  - Ungated: ~60 days.
- **Survival to spring outmigration:**
  - Top-mounted: <34%.
  - Self-regulating: ~50%.
  - Ungated: ~64%.
- Self-regulating gates significantly improve both access and utility of habitat, but timing of gate operation is critical for outmigration.

Interannual Variability

- 2024 “atmospheric river” event reduced passage success:
  - Top-mounted: <10%.
  - Self-regulating: <50%.
  - Ungated: unchanged.
- Highlights importance of considering annual hydrologic variability for gate management.

Key Takeaways

- Top-mounted gates severely restrict fish passage, residency, and survival.
- Self-regulating gates provide substantial improvement:
  - More fish approach, higher success, comparable time and effort to ungated sites.

    - Still potential for optimization (longer opening times, better upstream hydraulic conditions).
- Adaptive management of self-regulating gates allows:
    - Adjustment for tides, river flows, and changing hydrology.
    - Long-term flexibility in response to habitat, flood, and fishery management needs.
- Monitoring is crucial to understand fish behavior and optimize floodgate performance.

Questions

Have you tried to estimate the potential in productivity and survival at the population level that is impacted by existing gates?

- Riley Finn (UBC) has done this study (mapped the gates in the Lower Fraser River to determine the amount of upstream habitat that is blocked).
- Estimate that 85% of historical floodplain is locked away behind flood gates. How this rolls up to population recovery is 2-fold:
    - Fish growth would be higher and larger, healthier fish would be able to access floodplain habitat vs being forced to overwinter in the mainstem. Larger fish have higher survival.
    - Higher survival through winter translates into more smolts moving out of the river systems. Safety in numbers against predators.

And do you have any advice on how you could get some of the benefits of the self-regulating with the top mounted gate?

- Float systems that lift the gate up at high water levels. This is a retrofit because the gate itself and the culvert is not being changed. There's just a structure being added to it.
- Research suggests that any amount of time that the gate can remain open for longer will be beneficial to not only the connectivity, for native fish, but also to improve that habitat quality upstream.
- Lastly, PET doors that is putting a sluice gate door on the front of the top mounted gate to allow you an option to basically manually open that gate either during overwintering to allow fish in or during spring freshet to allow fish out.

Do you have recommendations for folks that aren't able to tag fish or have a really low budget, or just want to gather some information on the effectiveness of their project, or of a gate that they're trying to decide what to do with?

- Mike Pearson’s approach is the gold standard with telemetry and monitoring before and after, upstream and downstream of the gate.
- Zachary worked with a hatchery for his project. Great benefits and saved money.
- Zachary has built his own custom PIT-tag antenna system that cost approximately $300 in materials compared to $10,000 for a commercial antenna. This is published in Journal of Fish Biology.

- If PIT methods are too expensive, then traps, seining upstream/downstream is the next best option.

Has anyone looked at differences between wild and hatchery fish?

- Ariel Konig is a MSc student looking at this (UBC). Many other species moved through the gates. No difference in native/hatchery, so hatchery fish released early on act like wild fish.
- The timing and the success of approach was very similar between the limited wild population and the extensive hatchery population that we monitored in our study.

Panel Discussion

What are the most important things to look out for when assessing tide gates for fish passage? Is it long term operation, location, habitat, differences among species, or all of the above?

- GUILLERMO: need to assess it holistically and monitor function. Need to monitor it regularly. You can't build it and walk away.

- DAN: It is easy to under-estimate how important it is to determine WHO will manage/maintain the structure for the long-term (50-75+ years). Partners, land owners etc.

- JASON: In Oregon, Water Mangaement Plans are used, which are built into all projects. It's basically a Gate Maintenance Agreement. Projects shouldn't start without the agreement in place (though that's not a reality yet).

Stepping back, what are ways to get engagement and buy-in for projects? In Lower Fraser, First Nations often kick raise awareness about problem sites and start the projects. In Oregon, private land owners play a big role. What mechanisms get the buy-in?

- JASON: We deal primarily with land owners and they are already stretched thin, so we approach them with ideas to reduce their workload. Build trust and develop a relationship that will endure for the life of the project – this comes from local watershed councils, not big organizations. Approach the project from the land owner's view and speak the language of the land owner (they usually don't care about fish compared to the bottom line and keeping their land in production).

- DAN: Lower Mainland has high population and responsibility falls mostly on local governments and their priorities. The agency of a single individual to unlock possibilities in a small municipality can be great.

- ZACH: Monitoring can build trust, demonstrate function (eg, low salinity).

- GUILLERMO: Funding is always an after-thought, we need to invest a higher proportion of overall budget because we still know so little.

How are you incorporating climate change into decision making and project designs?

- JASON: Our tool can run different sea level rise projections to show different inundation scenarios and, depending on view, what the impacts of benefits might be. Scenarios can show landward migration zones, where habitat is built. We can also run different hydrology scenarios with changing snowpack/river flow/precipitation projections and look at miles of roads/railroads/urban areas that could be impacted. We are making decisions not for today, but for future conditions.

- DAN: Probably dealing with reduced freshet risk, but bigger AR events in winter and SLR. We are taking these future conditions into consideration, but First Nations and proponents usually already have those concerns. A lot of tide gates will need to be converted to pump stations in the future under SLR.

- GUILLERMO: SLR is the elephant in the room.

- ZACH: Water storage, floodplain habitats and wetlands are reduced so it exacerbates the problem. Re-opening habitat upstream of gates can help increase water retention.

How are farmers and agricultural groups involved in this problem? Agriculture and efforts to restore water ecosystems often clash. Is there a way to find common ground so both farming and healthy waterways can thrive together?

- JASON: The best advocate for a project is another farmer. It comes from coffee shop talks, farmers and land owners sharing their own experiences. Talking about water management in concert with tide gates – reassurance that newer gates manage water better and can help with flood resiliency, being left open in high water events. Farmers want to help each other, so positive water management is a good approach. Flood resiliency!

- DAN: Some farmers don't want salmon in their ditches, but others love fish. Each relationship is unique. Farmland Advantage Program – program run by Dave Zinder, in BC and it's an example of a program that pays for ecosystem services to encourage famers to take care of their ditches. Also Floodplains By Design in Washington is a great program that gets tribes, farmers and flood districts together.

What linkages to flood management are being considered in site selection or optimization? Has incorporating flood risk to communities / value of the land / land use been incorporated / potential for retreat (Craig Sutherland, Kerr Wood Leidal Associates Ltd)?

- JASON: Flood management isn't a part of our optimization process but water management is of the highest priority because it affects farming practices so much and translates to dollars.

- DAN: Craig was the design engineer on a project of ours a few years ago. We are looking to proponents to determine flood needs and risk. Water storage is so important, though BC Government is encouraging more development on the floodplain.

- ZACH: Agricultural land is not just important to farmers. It is also critical to other species (birds), people etc. If you lose farmland, you may impact other species. You can pair your tide gate restoration with upstream restoration actions to get greater value for fish and water storage. Tide gates aren't the only lever to affect water storage, flood risk.

- JASON: Bringing conservation money to the project isn't for gates specifically, but to couple with improving floodplain or tidal, wetland habitats behind the gates. It's only makes the project much more successful for water quality fish, wildlife, etc.

The problem will only get worse with increasing flood risk. Do land owners know who to go to start a project?

- GUILLERMO: Oregon has water councils supported by lottery funds.

- DAN: Watershed management in BC has not landed. There is a great effort being led by the Watershed Security Coalition and the Watershed Security fund that are newly released just last year. There is also the Lower Fraser Fisheries Alliance. But we are far from figuring it out in BC and it will likely need to be led by First Nations.

Has anyone had experience with passive fish ladders adjacent to top hinge tide gates to provide fish passage?

- GUILLERMO: there isn't the water level difference to use a fish ladder. You would need a dam, and fish ladders have many problems. Better to improve the existing structure, rather than add another artificial structure.

- DAN: I have seen cases where a pipe is installed beside a gate that provides continuous flow for fish. Dan doesn't have personal experience, but reports are from California. It would usually involve punching a hole through a dike.

What are the latest best options for practitioners?

- ZACH: We are trying to get information published based on our monitoring, which should really help improve the design of infrastructure. Our results show self-regulating is significantly better than top-mount gates. These data help promote the design and leverage funding for projects.

- JASON: There is still a great need for engineers and innovators. There is still room for improvement. Design competition at universities.

- DAN: It's the wild west in terms of gate design, no standards and lots of room for innovation.

Are there differences among life stages and species and their use of gates?

- GUILLERMO: Lots of focus on Chinook and estuary use. More focus should be on coho, nomads that move in and out of estuaries (Tschaplinski, Carnation Creek studies). It's been documented all along the Pacific Coast, possibly 20%. Tide gates block this life history behaviour and may impact survival. Eulachon is another species that may be impacted by gates that aren't leaky and allow mixing. Water quality impacts (salinity, temperature) are impacting >15 species.

- JASON: Plug for Pacific lamprey. Generally what works for salmon passage doesn't work for lamprey.

Co-hosts thanked all the presenters, participants and support staff for their role in supporting a success full day. *Adjourned: 4:30 pm*