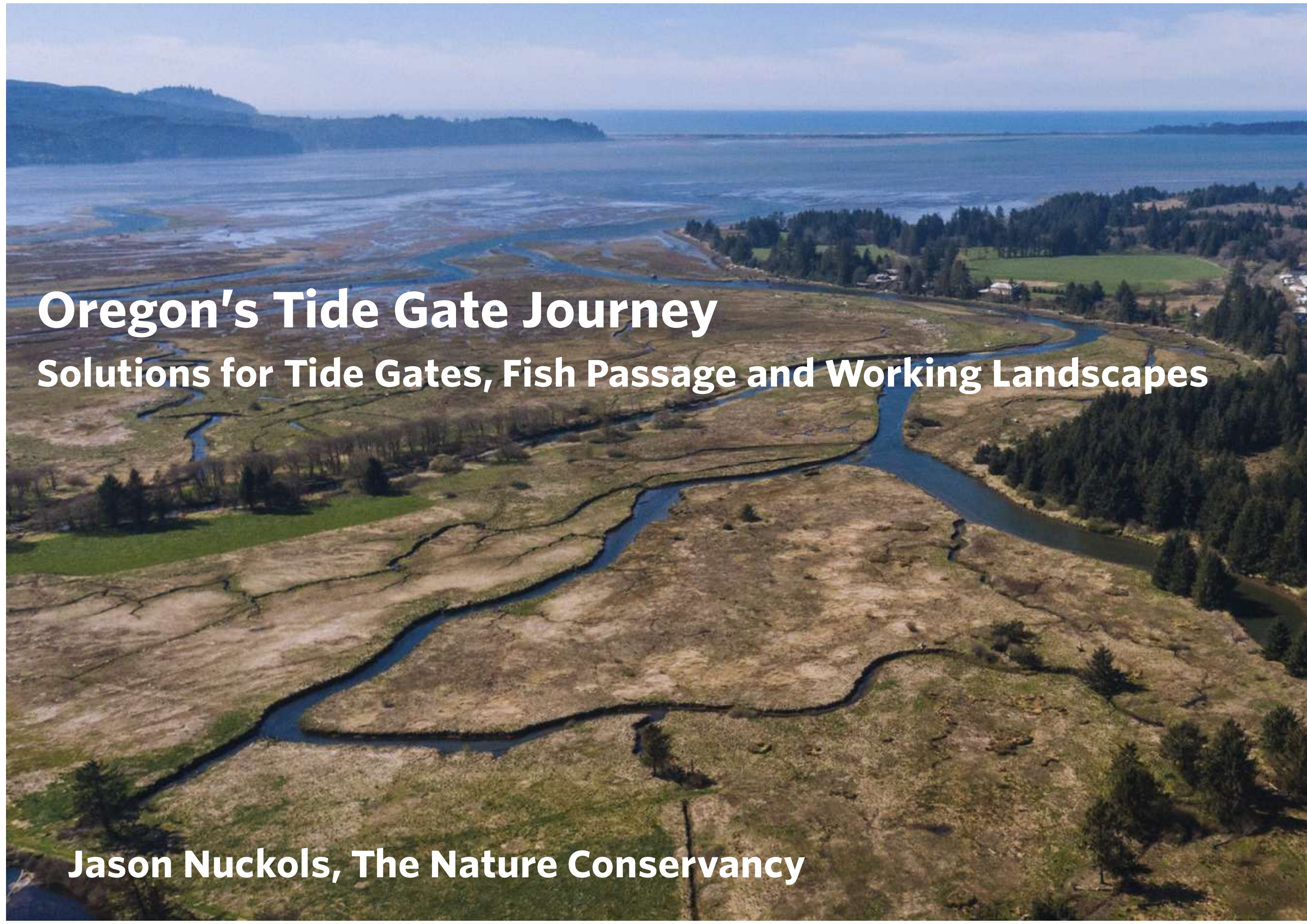

Oregon's Tide Gate Journey

Solutions for Tide Gates, Fish Passage and Working Landscapes

Jason Nuckols, The Nature Conservancy

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Outline

- Tide gate partnership
- Inventory
- Tide Gate Optimization
- Monitoring Protocols
- Landowner Benefits

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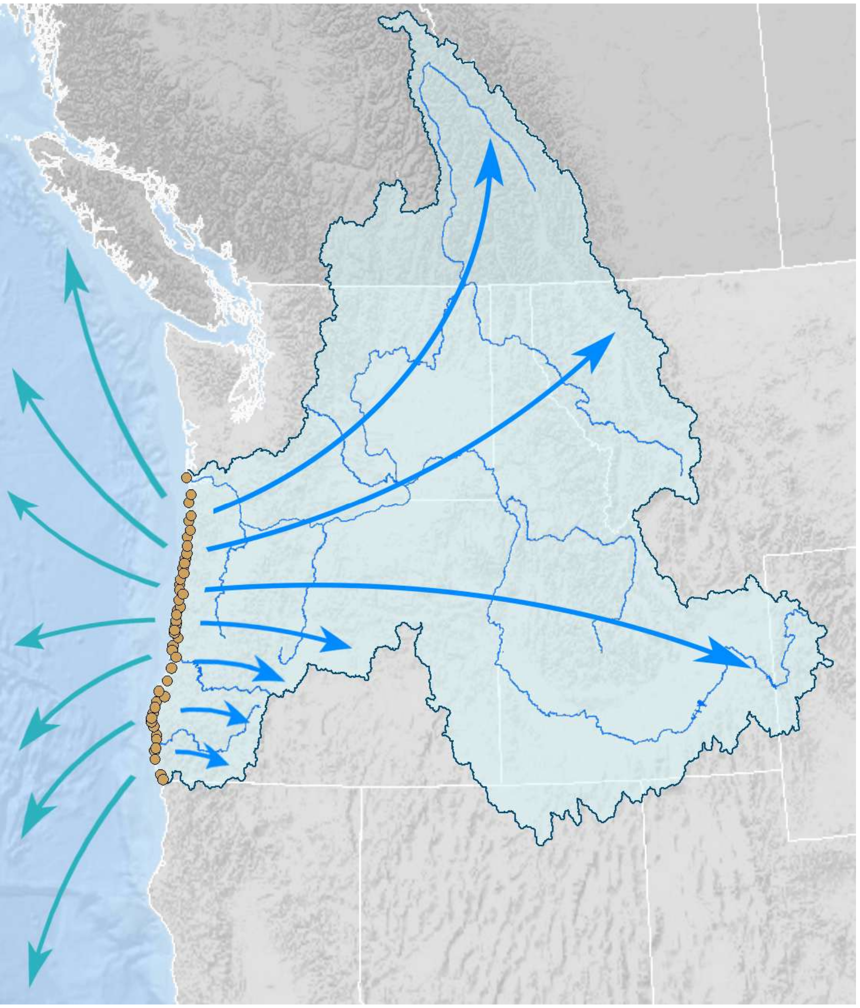

There are 69 estuaries in Oregon.

- The gateway to 172 million acres.
- Eight states and two provinces.

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Tide Gate Partnership

- Coordinated effort state and federal agencies, agriculture and conservation organizations, county leaders, and coastal landowners.
- Convened from 2017 – 2024 to understand the challenges related to tide gates in Oregon.
- Focused on solutions around funding, engineering and design, and permitting.
- Summary on Oregon Watershed Enhancement Board website

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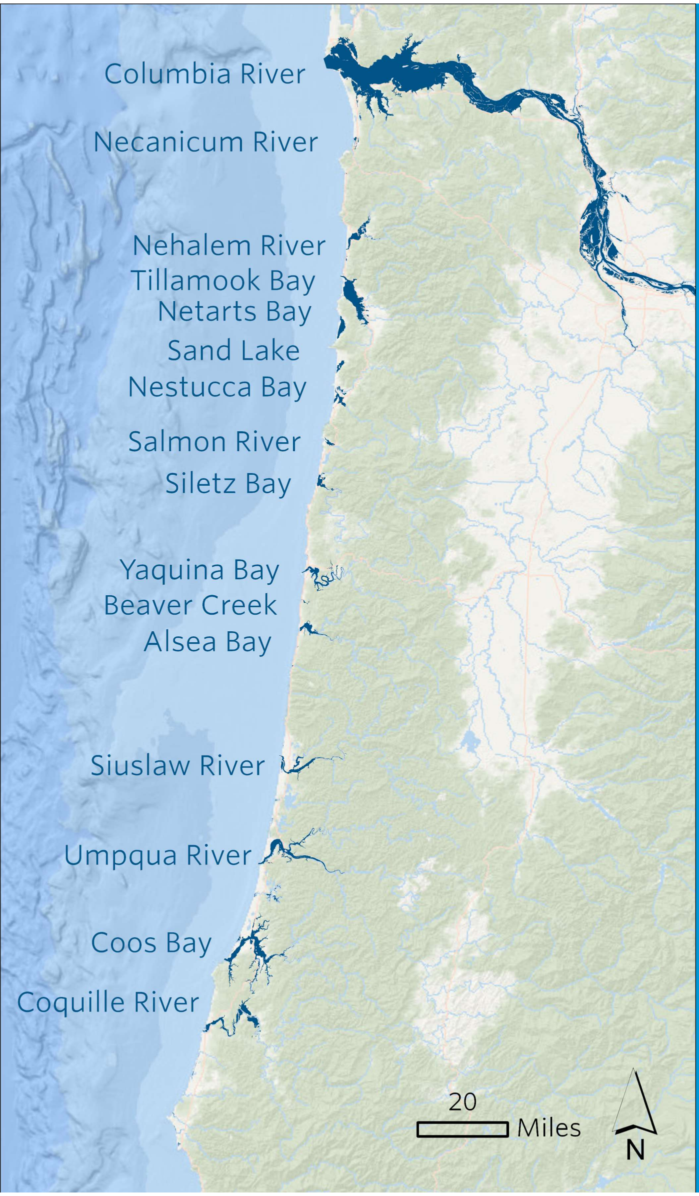
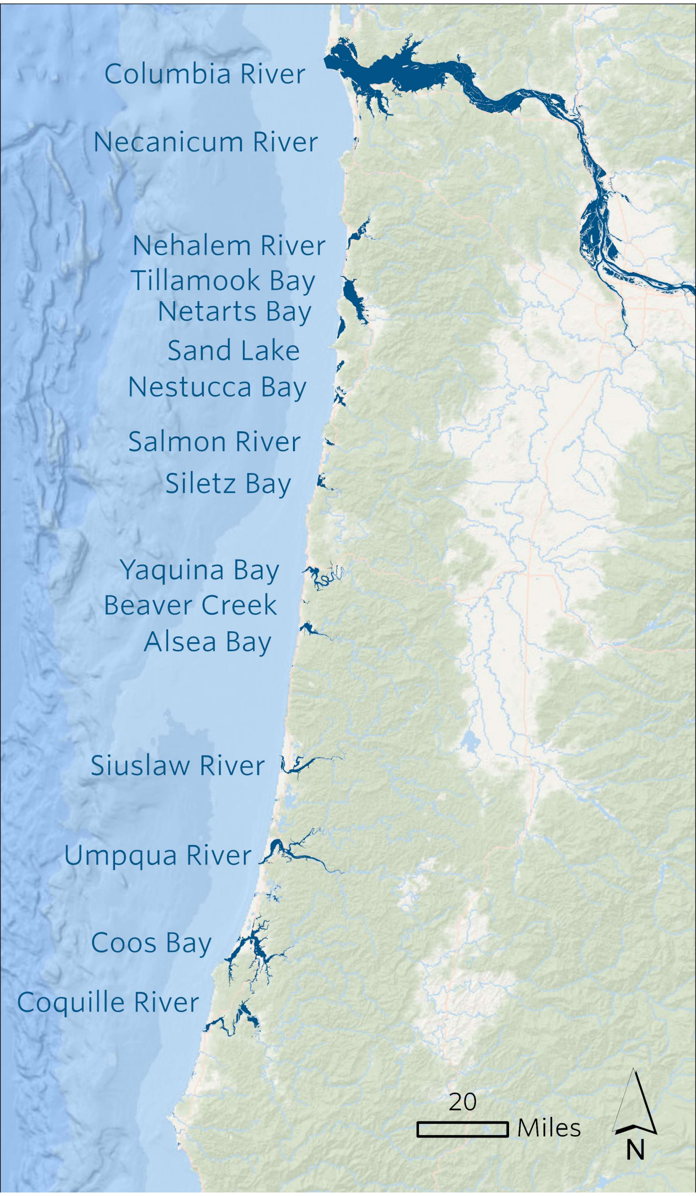


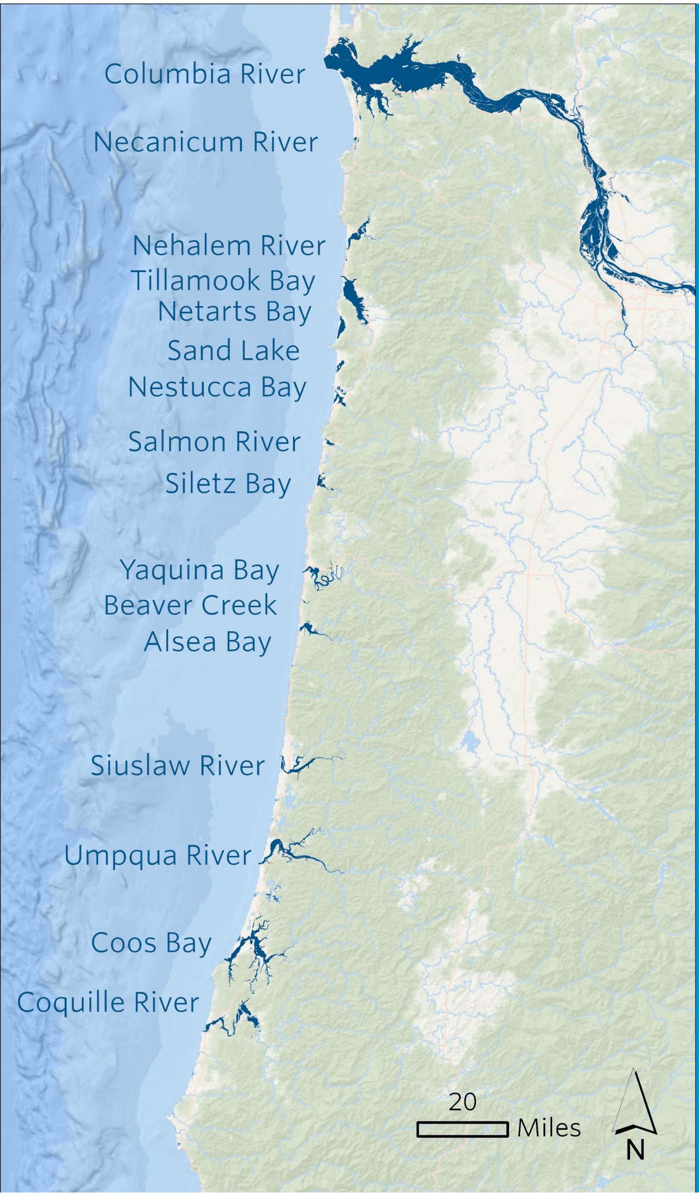
Inventory

- Two years ground and water-based surveys
- ~700 primary tide gates
- 1000s of secondary/interior gates
- Data resides on Oregon Explorer



Funding

- A State grant and loan program partially funded 20 planning and construction projects
- Across two funding rounds, NOAA (BIL) funded seven projects in Oregon, totaling $42.6 million.
- Additional substantial contributors include OWEB, ODFW, USFWS



Permitting

- Landowner Process Map
- Regulatory Process Map
- Agency Review Process Map
- NOAA released a programmatic biological opinion for tidal area restoration (including tide gate removal, replacement or retrofit) authorized, funded or implemented by the federal agencies in Oregon and the Lower Columbia.

TIDE GATE OPTIMIZATION TOOL

- Proven Base Model (OptiPass)
- Expanded to Consider Estuaries
- Addressing Stakeholder Needs
- Adding Functionality

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STAKEHOLDER INTERESTS

- Fish Habitat
- Agricultural Land
- Private Infrastructure
- Public Infrastructure
- Sea Level Rise

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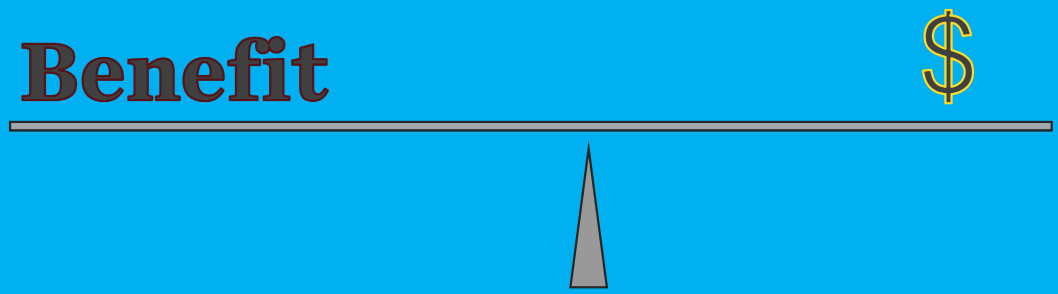
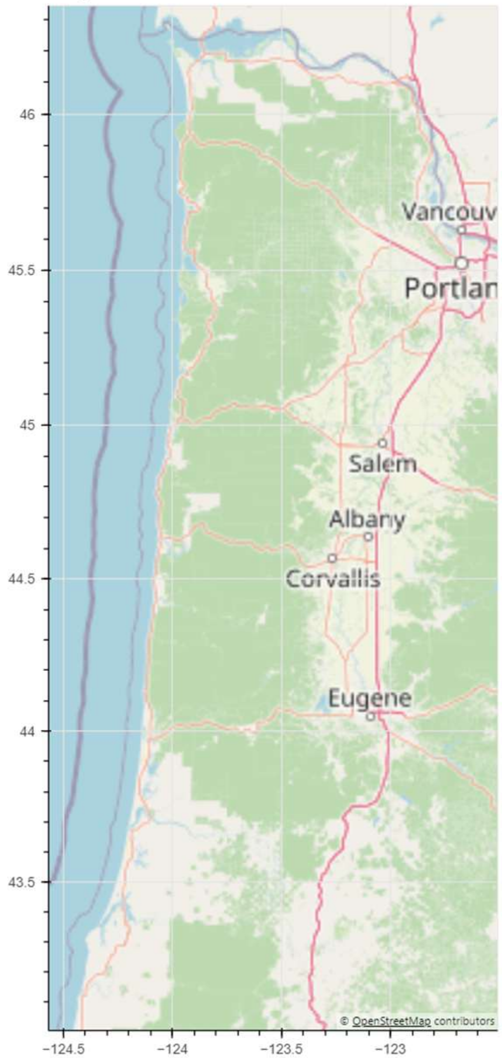
What is the **set** of tide gates and culverts in the watershed(s) that, if removed or replaced, could maximize **net gains** for a limited financial **budget**?



☰ Tide Gate Optimization

Oregon Coast



Home | Help | Start | Output | Download

Welcome

Tide gates on the Oregon coast are reaching maximum life expectancy. Replacing these gates will require a substantial investment in both time and money. To help landowners and other stakeholders decide which gates to focus on, The Nature Conservancy developed this **Tide Gate Optimization Tool**, a framework for evaluating tide gate replacement opportunities by integrating a variety of input data describing the region, benefit targets, and sea level rise scenarios.

This decision support tool balances the potential gain in benefits against the costs necessary to achieve those benefits. The tool is designed to answer the following question:

> *What is the set of tide gates and culverts in the watershed(s) that, if replaced, would maximize net gains for the benefit targets of interest, subject to a limited financial budget?*

In a general sense, the tool involves a flow of data between three actions: (1) preparing input data from field inventories, local knowledge, and a geographic information system (GIS); (2) constructing and executing optimizations; and (3) interpreting and integrating results in decision processes.

Running the Optimizer

Learn how to construct and execute optimizations by clicking on the **Help** tab above.

When you are ready to run the optimizer click on the **Start** tab.

Learn More About Tide Gates

For more information about tide gates, the role they play in the coast ecosystem, and the optimization tool download this PDF from The Nature Conservancy: Oregon's Tide Gate Optimization Tool.

Acknowledgments

This web site employs a widely used fish passage barrier optimization modeling approach: `OptiPass`™, a Microsoft Windows®-based program developed by Dr. Jesse O'Hanley of Ecotelligence® LLC. For more information on how the optimization process functions, see *OptiPass: The Migratory Fish Passage Optimization Tool*, Version 1.1.2 User Manual (O'Hanley 2017).

> OptiPass is distributed under the Gnu General Public License (GPL). OptiPass is provided free for non-commercial use. For all other uses a commercial license is required.

The web interface for this version of the tool was developed by John Conery and The Nature Conservancy. The interface is written in Python, using the Panel library developed by the HoloViz project (holoviz.org).

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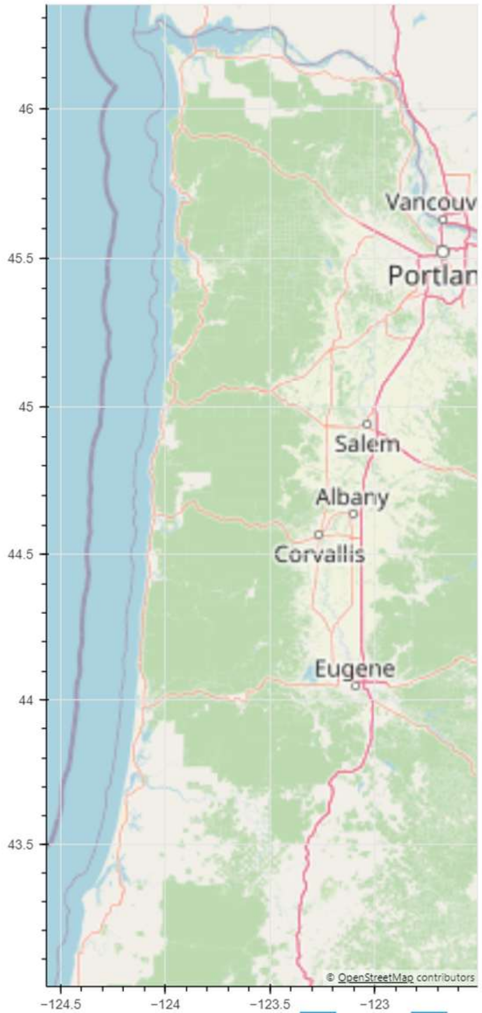
Tide Gate Optimization



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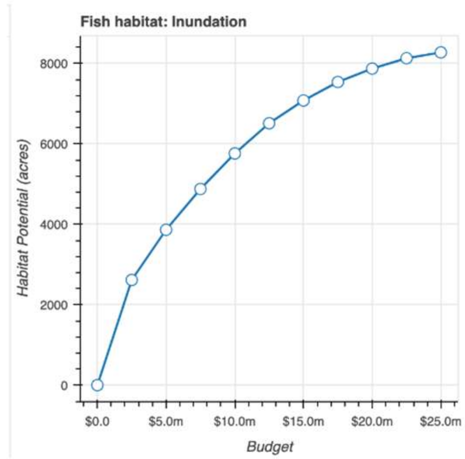
Instructions

The Tide Gate Optimization Tool is designed to help users evaluate the potential benefits of various levels of investment. To do this we run OptiPass several times, with increasing budget levels. The results can be plotted as a "return on investment" (or ROI) curve:



The goal for the plot shown above was to see the potential increase in the number of acres available for fish habitat. To make this plot we ran the optimizer 10 times, with budgets of $2.5 million, $5 million, *etc*, ending at $25 million.

> Since budget values can be large numbers we use abbreviations. $K stands for "thousands of dollars" and $M stands for "millions of dollars". For example, $2.5M is short for $2,500,000.

The circles in the plot show the potential habitat gained at each budget level. For example, at an investment level of $5M, the optimizer found a set of gates that would potentially add 4,000 acres of habitat.

ROI curves typically start to "flatten out" at some point. The area where the slope of the curve levels off indicates the point at which additional financial investment would provide diminishing gains.

Running the Optimizer

To run the optimizer for your area of interest you need to specify four types of information:

- The estuaries (regions) that contain the barriers you are interested in
- The range of budget values for the optimizer to consider
- The types of benefits you hope to achieve

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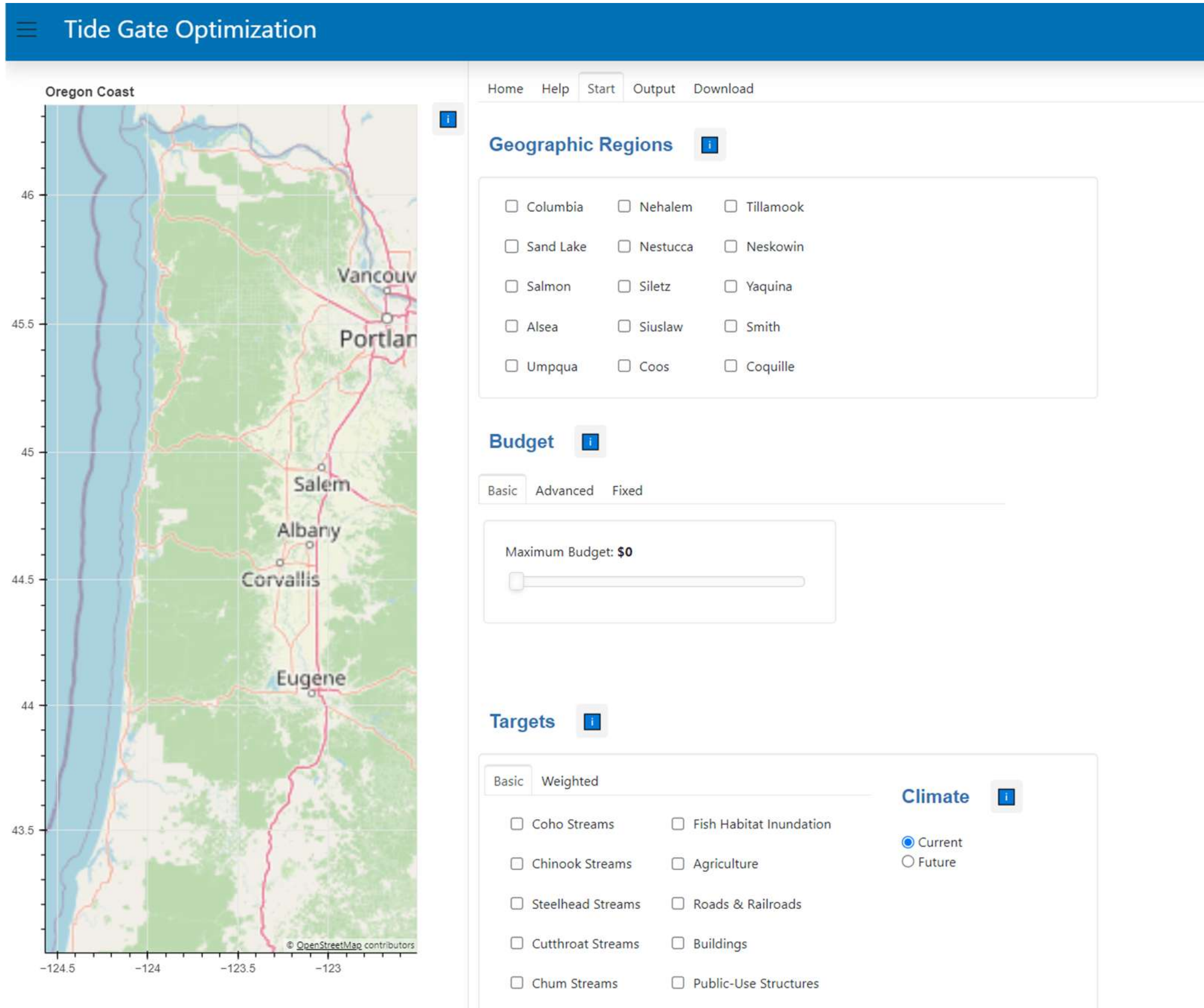

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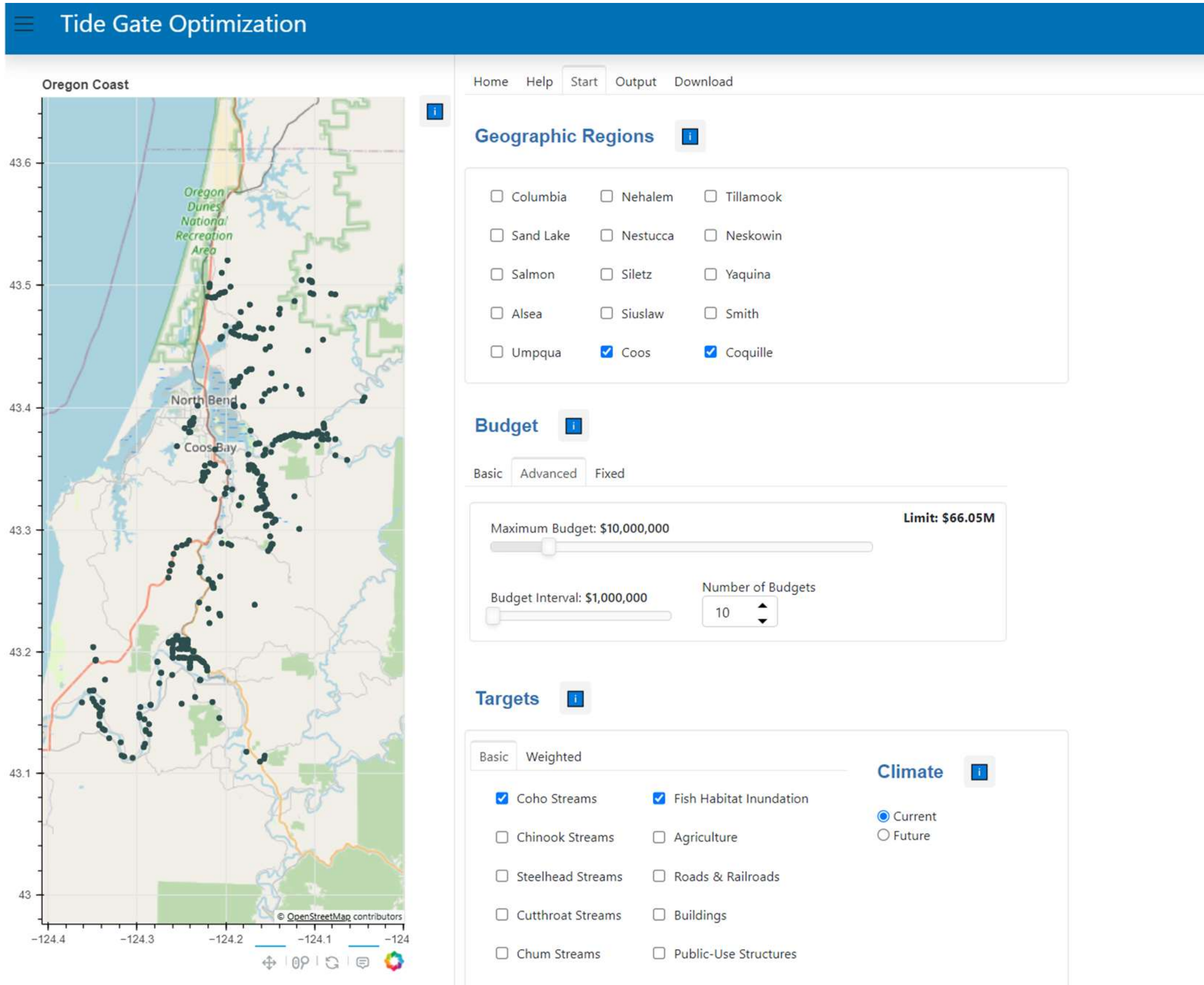

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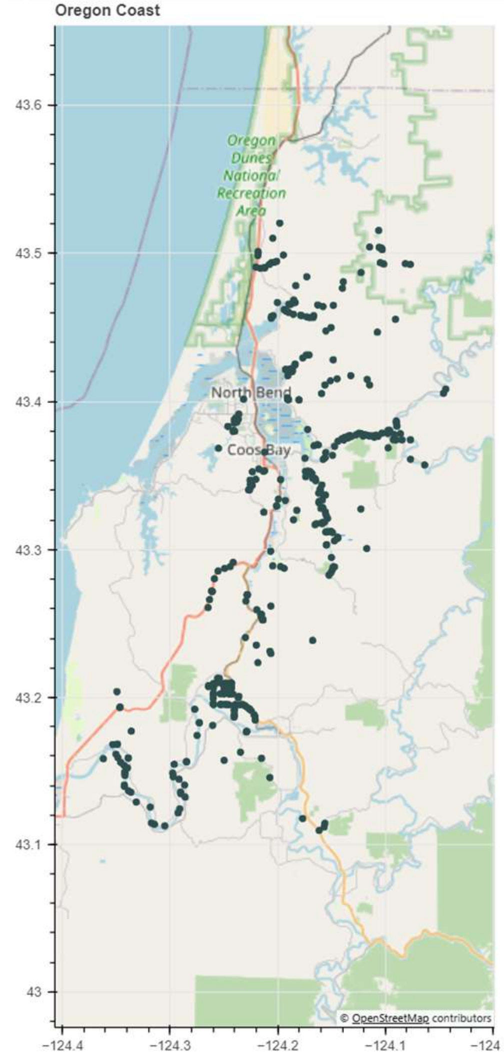
Tide Gate Optimization

Oregon Coast



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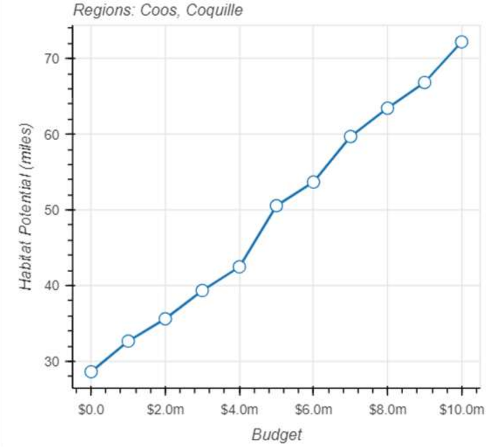
Optimization Complete

Regions: Coos, Coquille; **Targets:** Coho, Inund; **Climate:** Current; **Budgets:** $1M to $10M

ROI Curves

Net
Coho
Inund



Budget Summary

Budget	Net Gain	# Barriers	Coho	Inund
$0	1.9	0	28.6	0.0
$1,000,000	2.5	4	32.7	506.0
$2,000,000	3.1	4	35.6	1320.0
$3,000,000	3.7	5	39.3	1906.3
$4,000,000	4.1	9	42.5	2353.6
$5,000,000	4.7	6	50.6	2416.6
$6,000,000	5.2	10	53.7	2864.0

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Tide Gate Optimization

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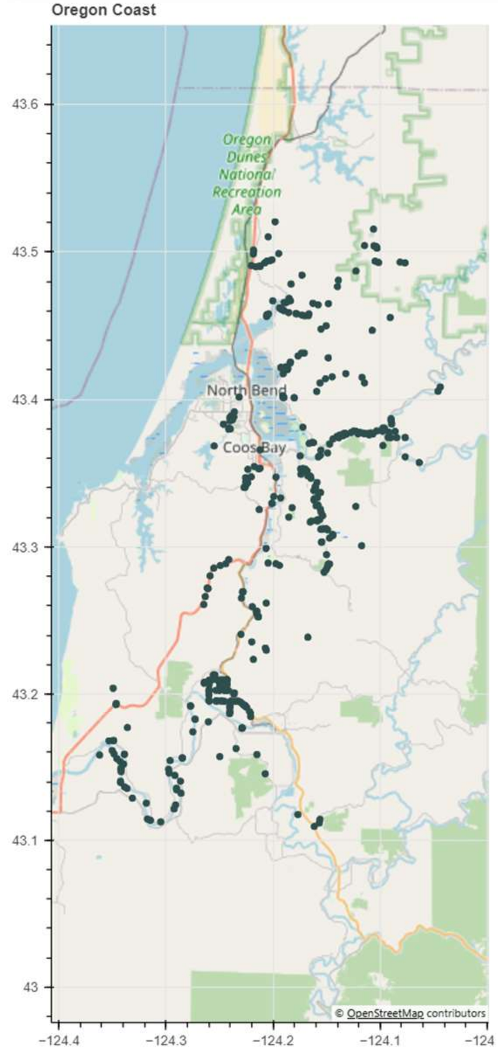
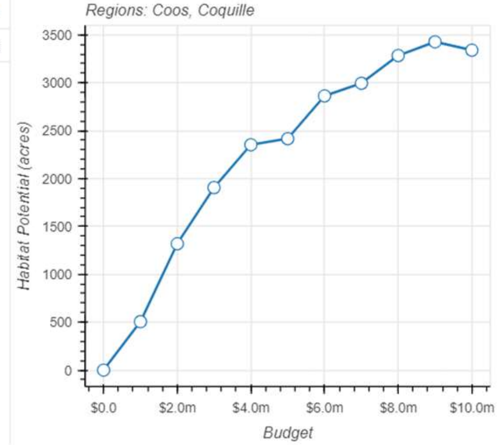


Optimization Complete

Regions: Coos, Coquille; **Targets:** Coho, Inund; **Climate:** Current; **Budgets:** $1M to $10M

ROI Curves

Net
Coho
Inund



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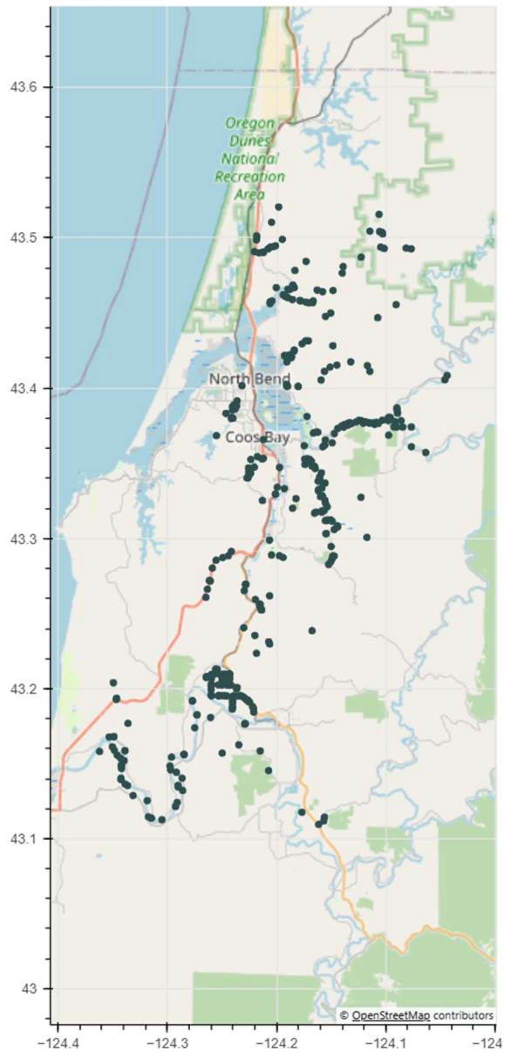
Tide Gate Optimization

Oregon Coast



$5,000,000	4.7	6	50.6	2416.6
$6,000,000	5.2	10	53.7	2864.0
$7,000,000	5.7	11	59.7	2994.9
$8,000,000	6.1	12	63.4	3284.7
$9,000,000	6.4	14	66.8	3427.7
$10,000,000	6.7	13	72.2	3340.6

▼ Barrier Details

ID	Region	Type	DSID	Cost	$1M	$2M	$3M	$4M	$5M	$6M	$7M	$8M	$9M	$10M	Coho	Inund
34ts1	Coquille	Tide gate	-	$260,000	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0.8	176.1
82ts2	Coos	Tide gate	-	$260,000	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	1.4	143.6
10Ats1	Coquille	Tide gate	-	$1,080,000		✓	✓	✓	✓	✓	✓	✓	✓	✓	3.1	825.0
161ts2	Coos	Tide gate	-	$540,000			✓	✓	✓	✓	✓	✓	✓	✓	2.7	197.9
36Ats1	Coquille	Tide gate	-	$810,000			✓	✓	✓	✓	✓	✓	✓	✓	2.7	563.7
14ts1	Coquille	Tide gate	-	$360,000	✓	✓		✓		✓	✓	✓	✓	✓	1.6	175.3
152ts2	Coos	Tide gate	-	$260,000				✓		✓	✓	✓	✓	✓	0.8	129.8
61Bts1	Coquille	Tide gate	-	$2,000,000					✓	✓	✓	✓	✓	✓	10.2	510.3
1ts2	Coos	Tide gate	-	$260,000				✓		✓	✓	✓	✓	✓	0.5	131.3
57ts2	Coos	Tide gate	-	$810,000							✓	✓	✓	✓	4.6	129.1
27ts2	Coos	Tide gate	-	$1,080,000								✓	✓	✓	0.3	236.1
72ts2	Coos	Tide gate	-	$100,000	✓			✓		✓					0.2	10.9
97ts2	Coos	Tide gate	-	$360,000							✓			✓	1.6	12.8
22ts1	Coquille	Tide gate	-	$260,000								✓	✓		0.8	66.5
2ts2	Coos	Tide gate	-	$200,000									✓		0.6	64.4
35ts1	Coquille	Tide gate	-	$1,900,000										✓	7.9	109.5
15ts2	Coos	Tide gate	-	$810,000									✓		2.8	78.7

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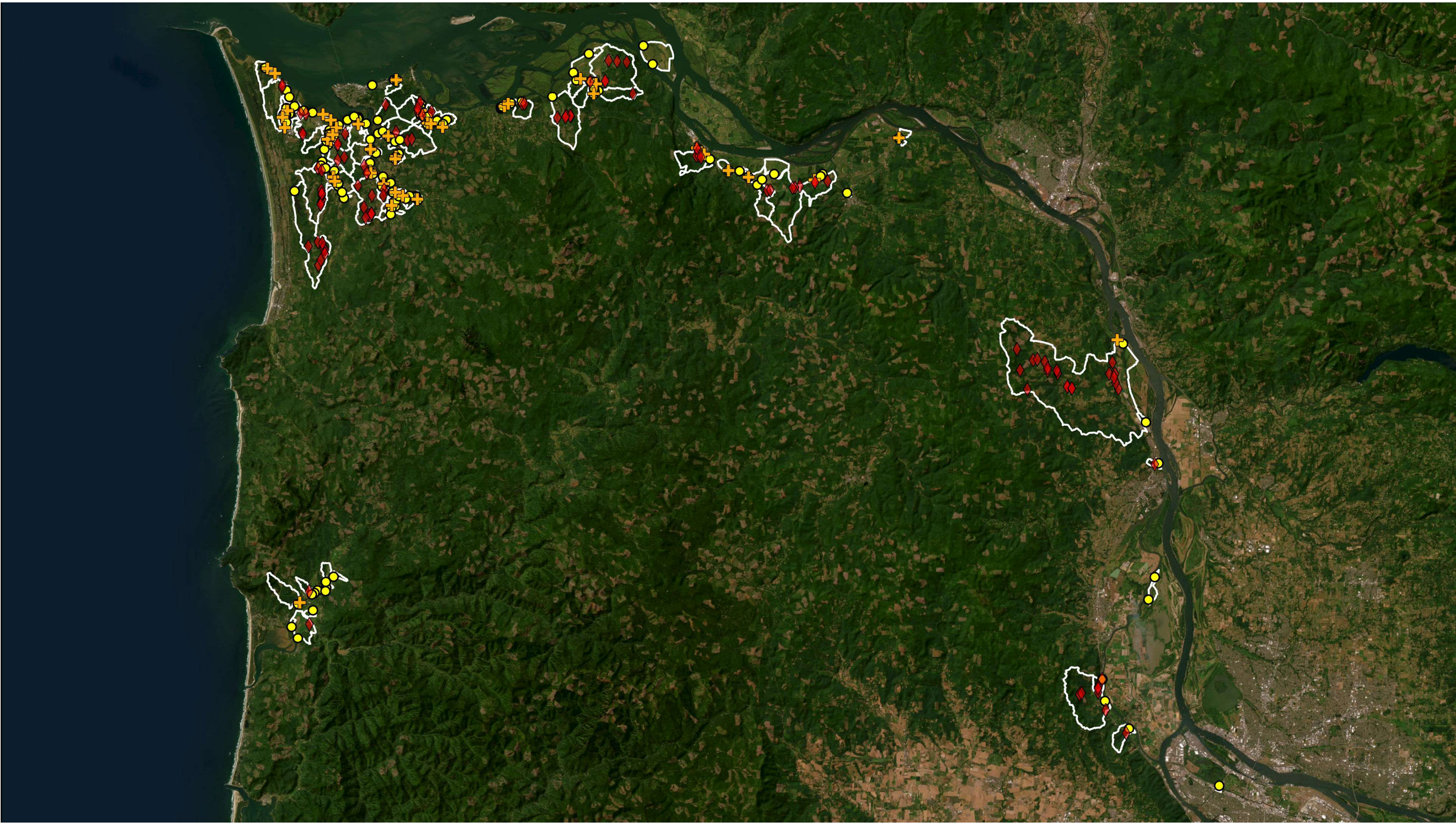
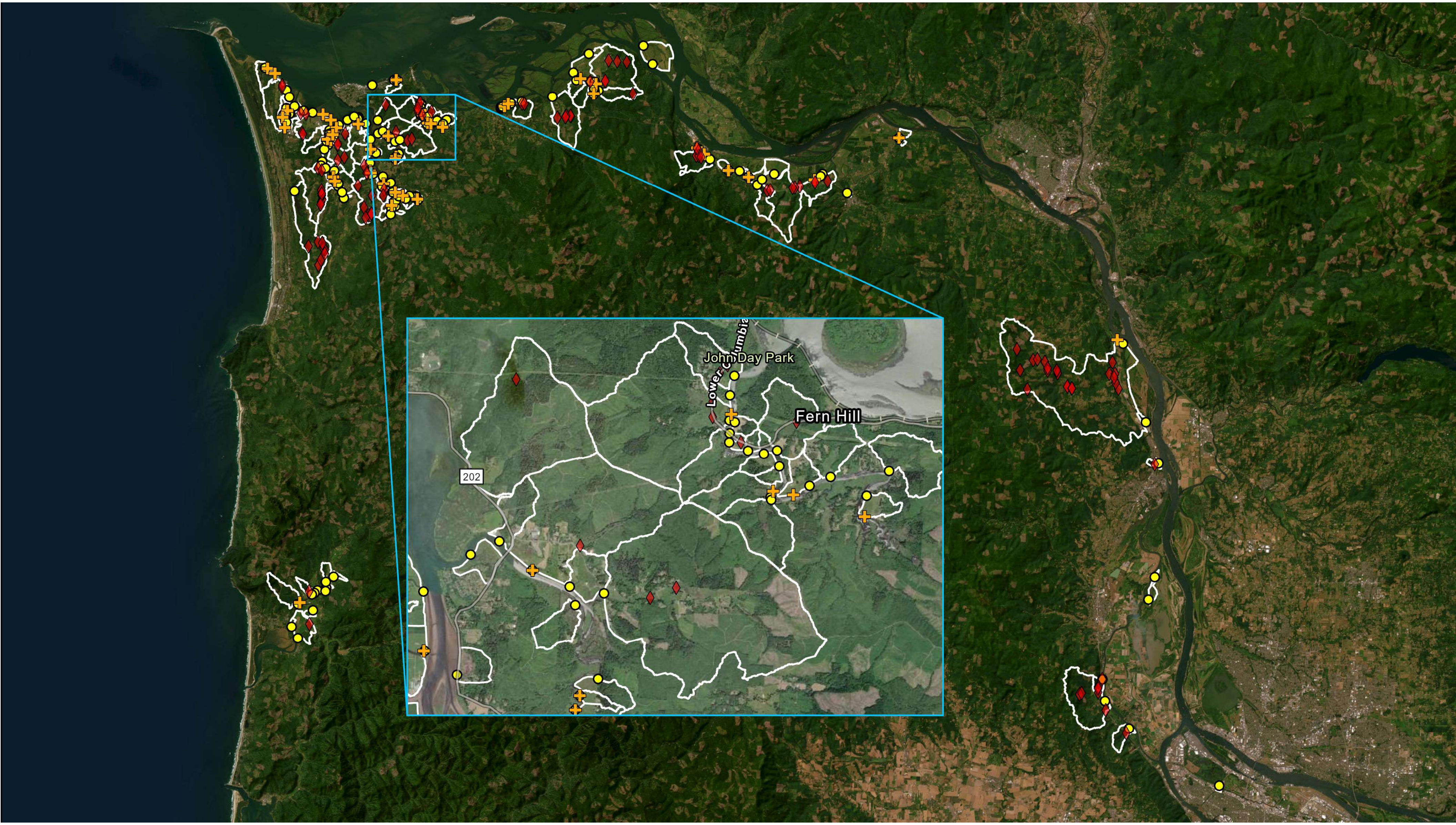
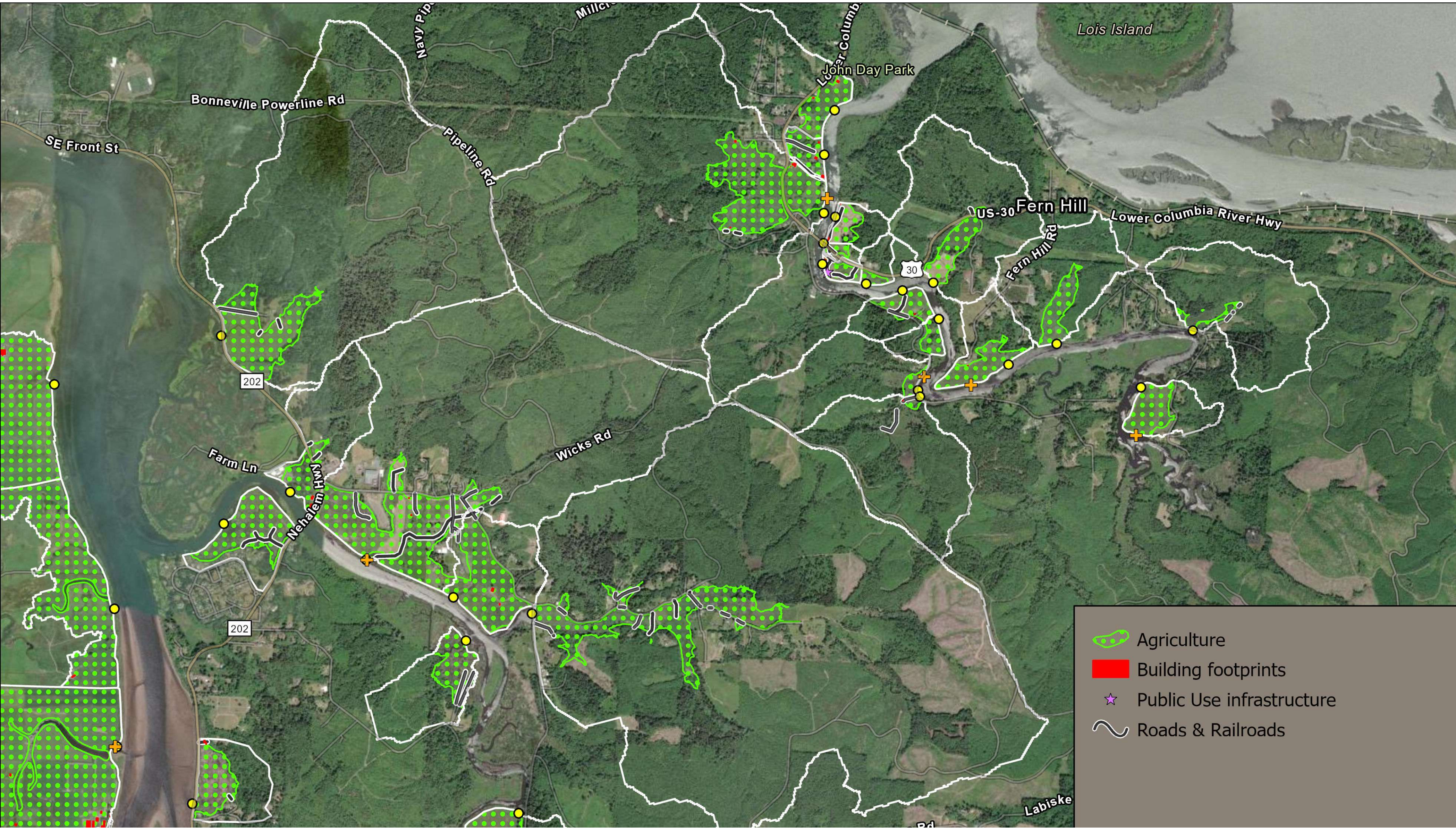



John Day Park
Lower Columbia
Fern Hill
202


Lois Island
John Day Park
Bonneville Powerline Rd
SE Front St
Pipeline Rd
Fern Hill
US-30
Lower Columbia River Hwy
Fern Hill Rd
30
202
Farm Ln
Wicks Rd
Nehalem Hwy
202
Pipeline Rd
Labiske Rd
Oregon State Parks, State of Oregon GEO, WA State Parks GIS, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, US Census Bureau, USDA, Maxar

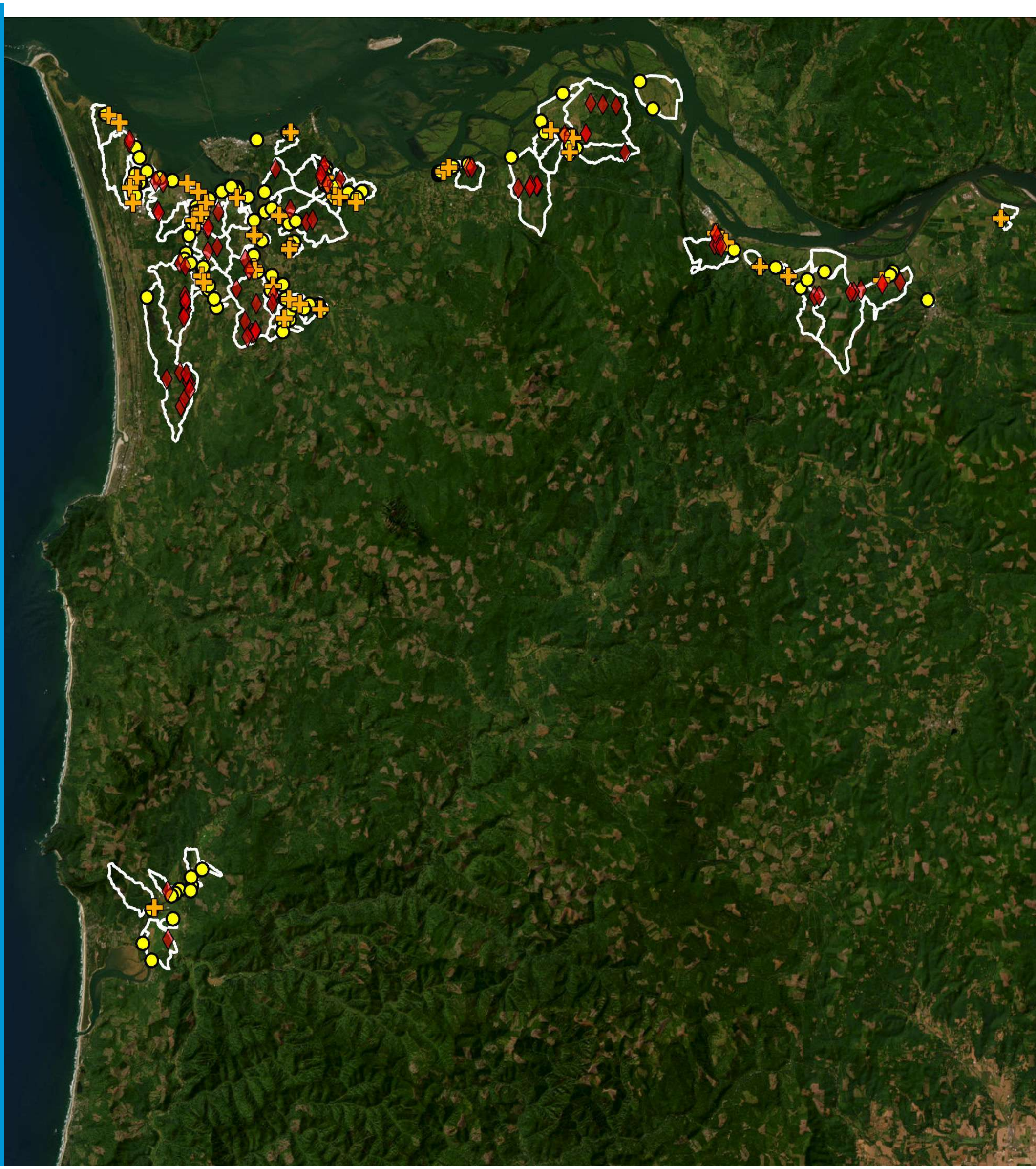
Lois Island
John Day Park
Lower Columbia
Bonneville Powerline Rd
SE Front St
Pipeline Rd
Navy Pipe
Fern Hill
US-30
Lower Columbia River Hwy
Fern Hill Rd
30
202
Farm Ln
Nehalem Hwy
Wicks Rd
202
Labiske
Barriers
Tide gate (primary)
Tide gate (non-primary)
Upstream culvert
Tide gate watershed

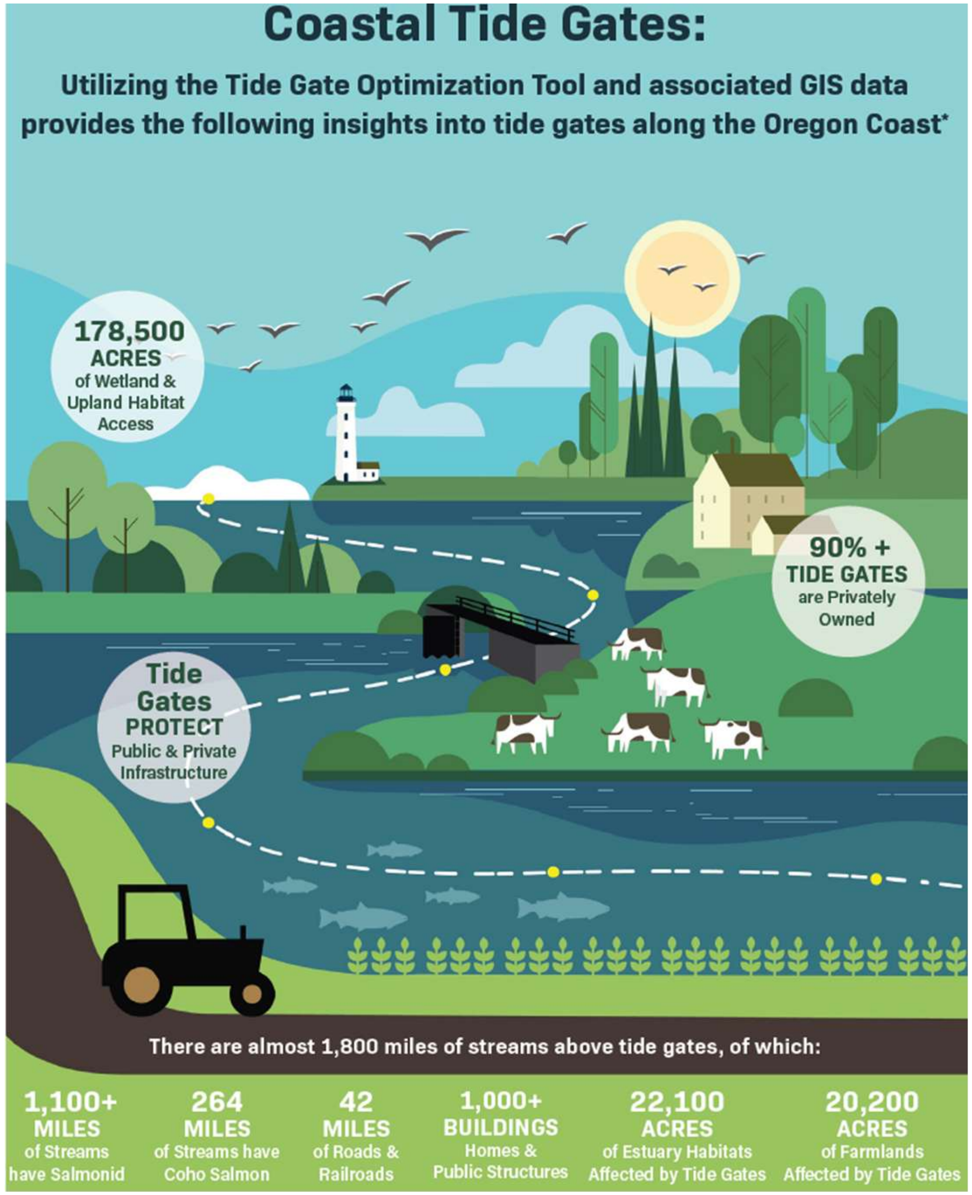
Lois Island
John Day Park
Bonneville Powerline Rd
SE Front St
Pipeline Rd
Navy Pipe
Fern Hill
US-30
Lower Columbia River Hwy
Fern Hill Rd
30
202
Farm Ln
Nehalem Hwy
Wicks Rd
Labiske
Fish Habitat
Chinook salmon
Chum salmon
Coastal cutthroat trout
Coho salmon
Steelhead
Inundation area
Other streams



Lois Island
John Day Park
Bonneville Powerline Rd
SE Front St
Pipeline Rd
Fern Hill
US-30
Lower Columbia River Hwy
Fern Hill Rd
30
202
Farm Ln
Nehalem Hwy
Wicks Rd
202
Agriculture
Building footprints
Public Use infrastructure
Roads & Railroads

Barriers	Columbia
Potential Influence	
Total tide gate watershed area (acres)	75,865
Total upstream length (miles)	615
Stream Habitat (miles)	
Chinook salmon	12
Coho salmon	69
Steelhead	31
Chum	18
Cutthroat trout	182
Benefit Summaries	
Agriculture - Current (acres)	15,776
Agriculture - Future	16,696
Inundation Habitat - Current (acres)	17,739
Inundation Habitat - Future	17,745
Road & Railroad - Current (miles)	75
Road & Railroad - Future	100
Buildings - Current (number)	2,083
Buildings - Future	2,373
Public Use Infrastructure - Current (number)	112
Public Use Infrastructure - Future	132





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Tide Gate & Tidal Wetland Monitoring

Guidance & Protocols for Estuary Practitioners

2024

Funded by the Oregon Watershed Enhancement Board (OWEB) in collaboration with the Coquille Watershed Association (CoqWA), The Nature Conservancy (TNC), and the Tillamook Estuaries Partnership (TEP).

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Tiered approach based on project scale

		Recommended Monitoring		
		Implementation	Compliance	Effectiveness
Scale I	Simple small non-self-regulating tide gate upgrades or replacements (no formal monitoring required, no fish and wildlife habitat, no water management plan).	X		
Scale II	Tide gate upgrades or replacements with SRTs, habitat, WMPs, etc).	X	X	
Scale III	Large complex tide gate upgrade or replacement projects and/or projects with an associated Monitoring and Adaptive Management Plan (MAMP).	X	X	X

- **Implementation monitoring**: was the project built as designed
- **Compliance monitoring**: is the project functioning as designed and meeting permit requirements
- **Effectiveness monitoring**: evaluates a projects performance and restoration efficacy

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Implementation Monitoring

- Completed for all projects
- Standardizes record keeping
- Simple datasheet
- Provides a means to quickly cross-reference similar information between projects
- ODFW Natural Resources Information Management Program

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Tide Gate Implementation Monitoring Datasheet

Please complete this sheet within six months of project completion.

Site name:	Report date:
Tide Gate Inventory ID #:	
Project manager/organization:	

Project Information

Project engineer firm and engineer name:		
Was the Pipe Sizing Tool* used for this project?		
Year of tide gate installation:		
Tide Gate Characteristics		
Style:	Model (if known):	# of gates:
Implementation date of other project elements (riparian planting, channel formation, etc.):		
Is compliance and/or effectiveness monitoring being conducted?		

Site Characteristics

Primary watershed name:			
Watershed area (acres):			
Miles of channel habitat upstream of tide gate:			
Tide gate coordinates as latitude/longitude in decimal degrees: (example: 43.176514, -124.228959)			
Water surface elevation at MHHW** at tide gate outlet (NAVD88*** feet):			
Water surface elevation at MLLW**** at tide gate outlet (NAVD88 feet):			
Area of project inundation at MHHW (acres):			
Area of project inundation at MLLW (acres):			
Project area elevation (NAVD88 feet):	Mean:	Min:	Max:

Compliance Monitoring

- Ensure regulatory and legal requirements are met
- Provides an objective assessment of project progress

Table 2 Compliance Monitoring Matrix. Note, color coding follows the Effectiveness Monitoring Matrix found below in **Table 3**.

Protocol ID[1]	Parameter	Monitoring Approach	Quantity	Frequency	Duration[2]	Performance Standard
1.2	Channel Water Level	Water level logger above and below tide gate	1 logger	15 min	Year 1/2	Maximum channel water level reached before tide gate door closes or tide gate operates in accordance with project's water management plan
1.3*	Gate Openness[3]	Water level logger above and below tide gate	2 loggers	15 min	Year 1/2	Tide gate is open 51% of time
1.4*		Direct gate location logger (gate angle)	Each tide gate	15 min	Year 1/2	
2.1*	Water Temperature	Temperature logger above tide gate	1 logger	15 min	Year 1/2	7-day average daily maximum temperature does not exceed 18 °C
4.6*	Velocity[4]	Float Measurement	1 location	2/yr	Year 1/2	Velocity does not exceed 2 ft/s
4.7*		Flowmeter	1 location	2/yr	Year 1/2	
5.2	Before/after photos	Photo monitoring	Inlet/outlet	1	Year B/1	Identify unforeseen tide gate infrastructure deterioration

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Goals	Monitoring Question Categories	Example Monitoring Questions	Protocol ID	Parameters	Monitoring Approach	Quantity	Frequency	Duration	Quantity	Frequency	Duration	Advanced Monitoring
Restore Hydrological Function	***Groundwater Connectivity***	*Is groundwater retained on site during summer?*	*[1.1]*	Shallow Groundwater Level & Duration	Water level logger in shallow well(s)	1 logger	15 min	Year 2	1+ logger	15 min	Year B/2/3/4/+	Paired well study, Offsite well monitoring
		Has groundwater salinity increased after restoration?	*[1.1]*	Salinity	Conductivity logger	-	-	-	1+ Wells	15 min	Year B/2/3/4/+	
	Tidal Connectivity	*Is the minimum water level behind the tide gate meeting the WMP?*	*1.2*	Water Level	Water level logger above and below tide gate	2 logger	15 min	Year 2	2+ loggers	15 min	Year B/2/+	Direct area of inundation measurements with temp loggers, Aerial mapping with drones
		How much of the tide cycle does the habitat experience during each phase of the WMP?	*1.3*	Gate Openness (Indirect)	Water level logger above and below tide gate	2 logger	15 min	Year 2	2 logger	15 min	Year 2/3/4/+	
		Is the tide gate open at least 51% of the time when species of interest are present?	*1.4*	Gate Openness (Direct)	Gate angle logger	-	-	-	Each TG	15 min	Year 2/3/4/+	
		Does the tide gate create a saline barrier for fish passage?	*[2.2]*	Salinity	Conductivity logger	-	-	-	2+ locations	15 min	Year B/2/3/+	
		How much land is inundated during mean water of each phase of the WMP?	*[1.5]*	Area of Inundation	GIS mapping through water level	-	-	-	1	Annually	Year B/2/3/+	
		How many stream miles are accessible during winter flows?	*[1.5]*	Floodplain Connectivity	GIS mapping through water level	-	-	-	1	Annually	Year B/2/3/+	
Improve Water Quality	***Water Quality***	*Does the tide gate create a thermal barrier for fish passage?*	*2.1*	Water Temperature	Continuous temperature logger	2 loggers	15 min	Year B/1/2	2+ loggers	15 min	Year B/1/2/3/+	TSS, DO, pH, bacteria, nutrients
		How far above the tide gate does saline water (>0.5 psu) penetrate during rearing periods?		Salinity	Handheld conductivity meter	2+ locations	1/yr	Year B/1/2	-	-	-	
		What are the maximum salinity levels observed in the project site compared to reference?	*2.3*	Salinity	Continuous conductivity logger	-	-	-	1+ logger	15 min	Year B/1/2/3/+	
Restore Wetland Vegetation	***Wetland Vegetation Development***	*Is plant community structure trending towards reference conditions?*	*3.1*	Vegetation Development	Photo Points	6+ points	annually	B/1/2/3	6+ points	1x/yr	B/1/2/3+	NPP, Aerial Monitoring (Drone)
		Is the overall cover of native species dominated plant communities increasing?	*3.2*	Vegetation Development	Mapping via aerial photo analysis	-	-	-	entire area	1x/yr	B/2/4/+	
		Is native woody plant density at least 300 trees & shrubs per acre?	*[3.3]*	Woody Plant Density	Stratified random sampling - Stem count	-	-	-		1x/yr	B/1/5/10/+	
		Does native plant cover exceed 50% within 5 years of restoration?	*[3.3]*	Herbaceous Plant Community Composition	Stratified random sampling - Species cover	-	-	-	25+plots/100m baseline	1x/yr	B/1/3/5/+	
		Is there a 60% or higher survival rate for native plantings?	*[3.3]*	Revegetation Success	Stratified random sampling - Survivorship	-	-	-	10 plots/ha	1x/yr	1/2/3/+	
	Invasive Species	*Are invasive species recolonizing this site?*	*3.4*	invasive species extent	Photo Points	1+/infestation	annually	B/1/2/3+	1+/infestation	annually	B/1/2/3+	-
		Are invasive species dominated plant communities decreasing in treatment areas?	*3.5*	Area of Infestation & Treatments	GIS mapping	-	annually	B/1/2/3+	-	annually	B/1/2/3+	
Improve Native Fish Populations	***Fish Presence/Absence***	*Are juvenile salmonids using the project site during rearing periods?*	*4.1*	Presence/Absence	Snorkel	1+ location(s)	1x + /yr	Year B/2	-	-	-	Density
		Are juvenile salmonids using the project site during rearing periods?	*4.2*	Presence/Absence	Seine netting	1+ location(s)	1x + /yr	Year B/2	1+ locations	3x + /yr	Year B/2/3/+	
	Fish Abundance	*Has the number of juvenile salmonids using the site increased?*	*4.3*	Catch Per Unit Effort	Seine netting	-	-	-	1+ locations	3x + /yr	Year B/2/3/+	Density
		What fish species (native/non native) are using the site?	*4.4*	Community Composition	Seine netting	-	-	-	1+ locations	3x + /yr	Year B/2/3/+	
	Fish Growth	*Are salmonids growing faster on site than a similar ODFW life cycle monitoing site?*	*[4.5]*	Fork Length	Seine netting	-	-	-	1+ locations	3x + /yr	Year B/2/3/+	Genetics
		What is fish growth after restoration?	*[4.5]*	Weight	Seine netting	-	-	-	1+ locations	3x + /yr	Year B/2/3/+	
	Fish Passage	*What range of water velocities do fish prefer during passage?*	*4.6/4.7*	Velocity	¥	-	-	-	-	-	-	Continuous velocity; PIT arrays; video arrays
	Fish Habitat	*Have the number and distribution of complex channel features increased over time?*	*4.8*	Channel Morphology	Side Channel Morphology	-	-	-	1+ locations	1/yr	B/2/5/+	Channel Morphology via main channel profile
		How have mussle populations responded to tide gate upgrades?	*4.9*	Presence/Absence	Freshwater Mussel Survey	1+ location(s)	1/yr	Year B/2	2+ locations	1/yr	Year B/2/3/5	Macroinvertebrates
Suppot Climate Mitigation	***Carbon Sequestration***	*tbd*	-	Soil Carbon Content	±	-	-	-	-	-	-	
		tbd	-	Above Ground Biomass	±	-	-	-	-	-	-	
	Sediment Processes	*Is the site gaining or losing elevation for the purpose of maintaining estuary habitat types?*	*5.1*	Accretion Rate	Sediment Accretion Plots	-	-	-	5+ plots	1/yr	B/5/+	geomorphology?; soil compaction;

4.5 Fish Growth

Fork Length & Wet Weight

Many tide gates are replaced to improve fish passage and increase access to habitat behind the gate. Juvenile salmonids grow at a faster rate in these off-channel wetland habitats. Measuring fork length and wetted weight of juvenile salmonids is a key metric to illustrate increased body condition of fish in these restored and accessible habitats.

Materials

- Waterproof gram scale
- Measuring board
- 5-gal buckets (2-4)
- Battery operated bubblers (2-4)
- Hand bait net
- Anesthetic (MS-222)
- Datasheet

Field Summary

- Sample fish captured by seining (Protocol 4.2) or other means
- Anesthetize fish before handling
- Allow fish to fully recover in a freshwater recovery bucket before release

Miscellaneous

- A measuring board can be purchased or made with 4"PVC pipe, a cloth measuring tape and fiberglass resin
- An ODFW permit is needed for handling non-ESA listed fish
- A NOAA permit is needed for handling ESA listed fish

Design

Wet weight and fork length of juvenile salmonids are essential biometrics of their growth and health.

Fish should be captured and measured upstream of the tide gate from a minimum of one location during baseline data collection. Refer to the seine netting protocol (4.2) in this handbook for fish capture methods. Since most tide gates are operated modestly immediately after installation to allow the land to recover, monitoring should start when the tide gate is operating according to a water management plan, typically after a year has passed, therefore, monitoring of fish biometrics post-restoration should start in year 2. For year-to-year comparison, sample at similar timing throughout the season so sampled fish are of similar age.

If funding and capacity allow for expanded monitoring design, consider seining and measuring fish at multiple locations behind the tide gate and one location in front of the tide gate.

Permitting: To capture, handle and anesthetize fish in the state of Oregon a scientific take permit is required, furthermore, if the expected fish are ESA listed a 4(d) permit is needed through NOAA.

Field Tips:

State and federal permits are required to anesthetize and handle juvenile salmonids.

Methods

Procedure: Keep all captured fish in holding tanks of freshwater (5 gallon bucket or similar) equipped with a battery powered bubbler to ensure adequate dissolved oxygen. Set up the scale on a flat surface, use a small wetted plastic tray with the scale. Tare the scale to account for tray weight. Set up the measuring board on the ground, table or on top of a 5 gallon bucket and place a small amount of water on the measuring board so the fish stay wet. When setup is complete, mix 5 mL of a 60 mg/L MS-222 solution into 2.5 gallons of water in a 5 gallon bucket outfitted with a bubbler. When all personnel are ready, place 10 fish in the anesthetizing bucket. Once the first anesthetized fish has stopped swimming remove it from the bucket with a hand net. Place the fish onto the scale, record the weight to the nearest 0.1 g. Move the fish to the measuring board and measure from the tip of the snout to the fork in the tail (the V-shaped indentation where the caudal fin splits into two lobes). Record the length in millimeters. Move the fish to the freshwater recovery bucket. Repeat with all remaining fish in the anesthetic bucket, and continue processing all of the fish in batches of 10. Fish are ready to release back to the capture location once they are active and the anesthetic has worn off, roughly 20 minutes.

Field Tips:

To improve fish recovery, intermittently swirl the water of the recovery bucket to get freshwater passing through the gills of the recovering fish.

Data Analysis: To compare multiple years of data use various statistical tests and techniques. For example, a one-way ANOVA (Analysis of Variance) test is a simple approach to determine if fork length or weight are significantly different from year to year. Organize the data by year and sampling period (so similar aged fish are compared). Run a one-way ANOVA test in excel or R for each sampling period. The ANOVA test produces an F-Statistic and a p-value. If the p-value is less than 0.05 this indicates there are statistically significant differences in the weight and lengths from year to year.

References

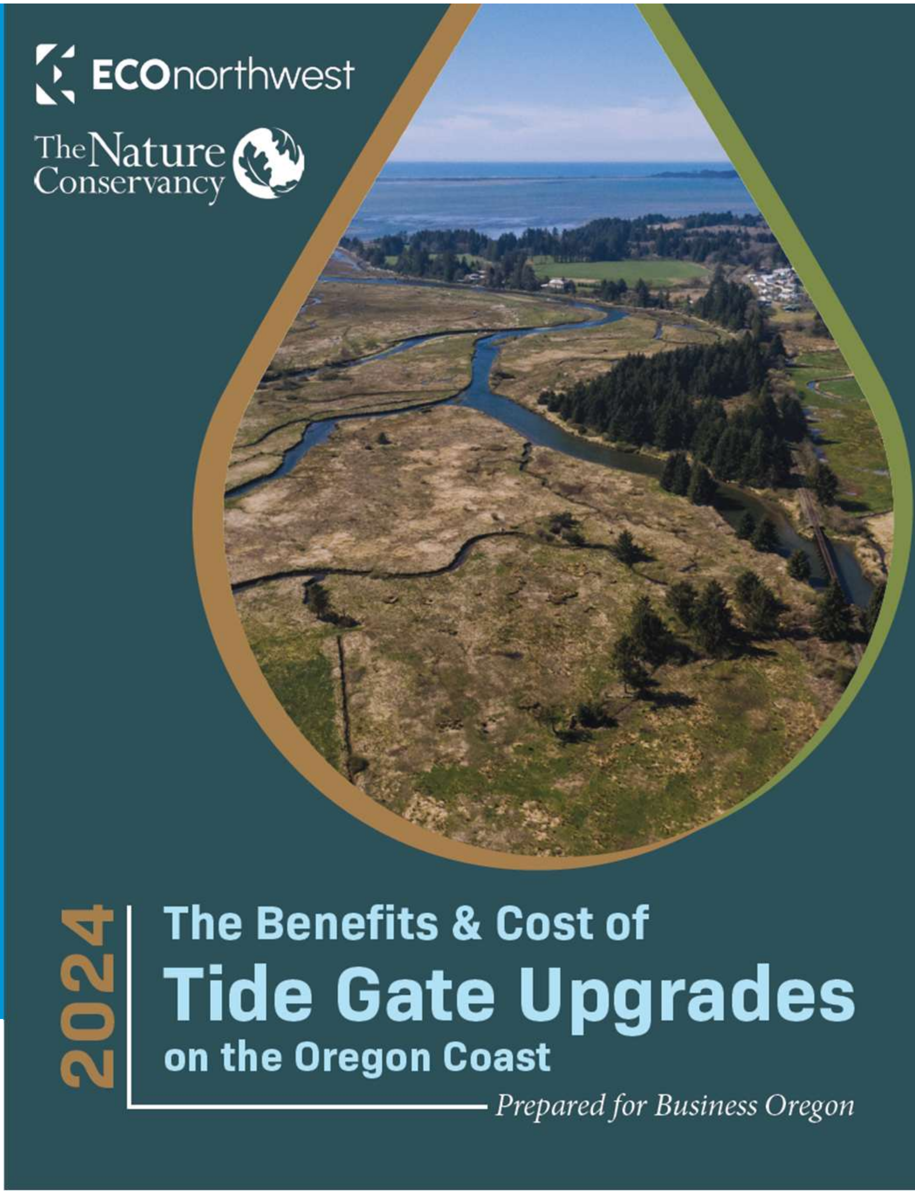
Feldhaus, J.W., & Wilson, W.H.. 2021. ODFW Hatchery Monitoring and Evaluation: Juvenile fork length and weight. Monitoring Methods http://www.monitoringmethods.org/Method/Details/458

PTSC (PIT Tag Steering Committee). PIT tag marking procedures manual, version 3.0. 2014.

Field Tips:

Windy conditions make scale readings inaccurate. Temporary wind breaks can be created out of sampling gear or the scale can be placed in an extra bucket lying down on it's side.

- 95% of agricultural acreage is devoted to grassland and/or pasture for grazing
- 69% of all farmlands in the estuary are affected by tide gates
- Water management directly impacts land value, grazing and crop yields



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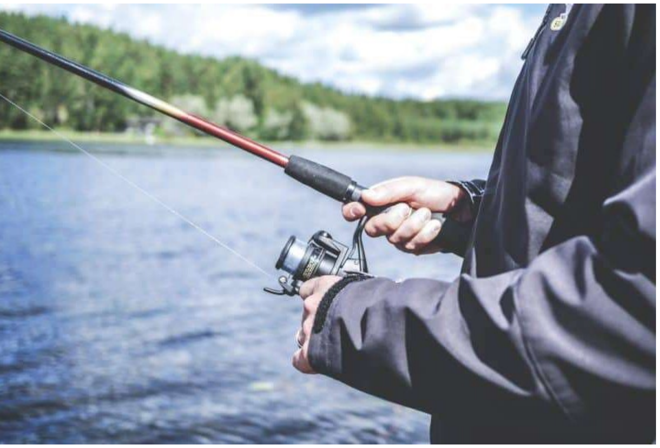

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