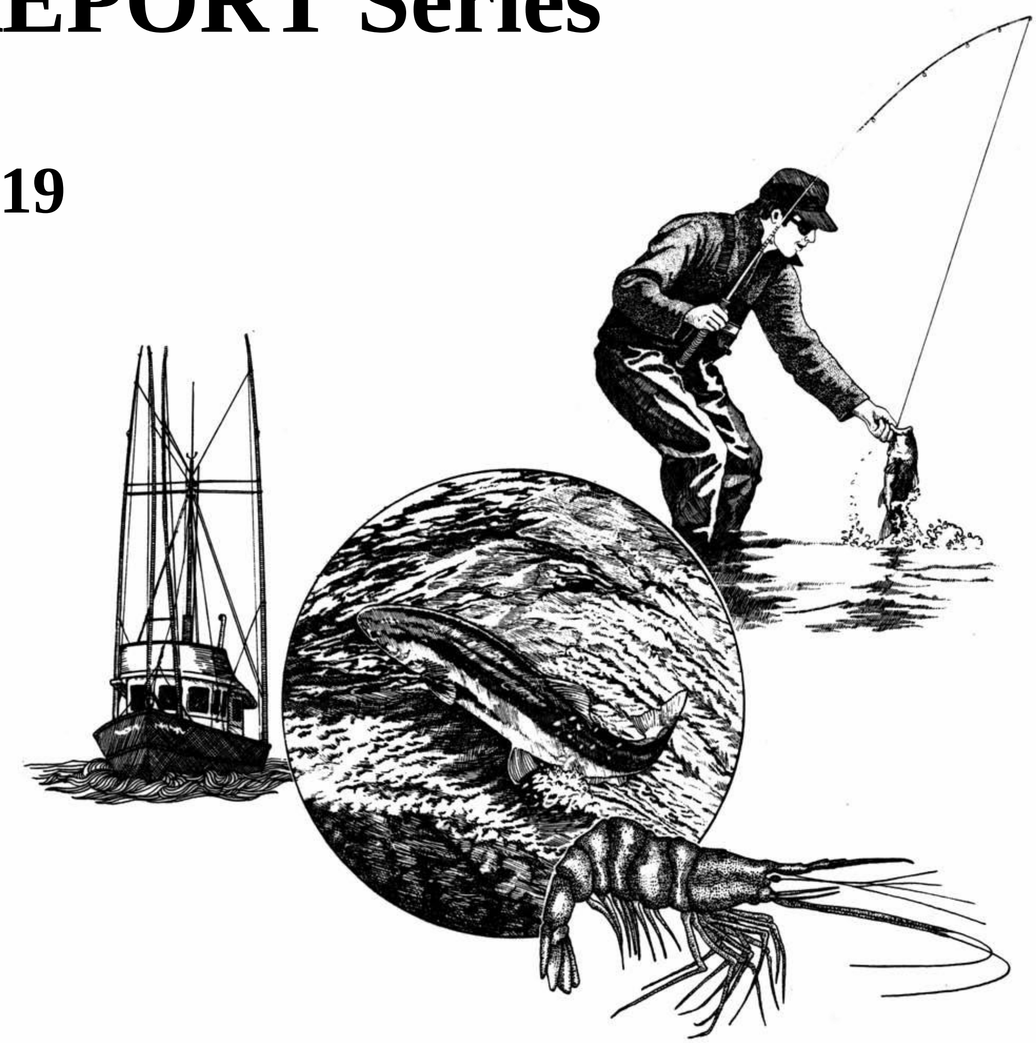
ODFW PROGRESS REPORT Series

2019



Oregon Department of Fish and Wildlife

Use of a Side Scan Sonar to Describe Habitat Condition in the Columbia Slough

Progress Report No. OPSW-ODFW-2019-5

PROGRESS REPORT
FISH RESEARCH PROJECT
OREGON

PROJECT TITLE: Use of a Side Scan Sonar to Describe Habitat Condition in the Columbia Slough

PROJECT NUMBER: OPSW-ODFW-2019-5

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Abstract

In this report we summarize data collected from the Columbia Slough in Portland, Oregon. We utilized a 1199CI HD Humminbird side imaging system set to obtain continuous sonar imagery from a jon boat. During a two week period in May of 2019 we surveyed over 35 kilometers of slough habitat across seven individual reaches and four channel types. Data were downloaded using SonarTRX version 17.1 and visually displayed using Google Earth Pro. We measured every piece of wood that met minimum size criteria along with the area of rock substrate and artificial structure. Depth, width and length measurements were collected at every tenth transect. Average width, depth and overall wood volume (m^3) were generally higher in reaches 1 and 2. In most reaches key pieces of wood were nonexistent and overall, reaches 3-4 and 6-7 were wood deficient. Artificial structures were relatively evenly distributed, although reach 1 contained the highest percentage compared to other reaches. Overall, the presence of natural rock was minimal and it can be assumed mud and silt comprise >99% of the Columbia Slough substrate.

This report is organized into the following summaries for describing habitat conditions in the Columbia Slough:

1) Summary of channel dimensions.

2) Summary of wood that met minimum size criteria.

3) Summary of rock substrate and artificial structures.

Introduction

The Oregon Department of Fish and Wildlife's Aquatic Inventories Project worked in collaboration with the City of Portland to describe current aquatic habitat condition within the Columbia Slough. The survey started at the confluence with the Columbia River near Kelley Point Park and extended just west of Fairview Lake. We described seven individual reaches consisting of four channel types; primary, secondary, tributary and alcove (Moore et al. 2019).

This report discusses findings from a survey design developed for non-wadeable habitat. Due to the nature of the slough and habitat characteristics we conducted a continuous survey using a side-scan sonar and methods developed by Kaeser and Litts (2010). Our goal is to develop methods for state-wide application and the Columbia slough was viewed as an opportunity to describe habitat in an environment outside of complex or technical flow influence (ex. rapids and channel sinuosity). We (1) describe reach boundaries and general characteristics (2) channel area and depth profiles, (3) structure and complexity, and (4) a guide to interpreting sonar imagery.

Methods

Study Area

The Columbia Slough is a low gradient (<0.001% slope) channel that begins at Fairview Lake and flows generally west 31 kilometers to the confluence with the Columbia River near Kelley Point (Figure 1). The slough flows almost entirely within the city of Portland and is to adjacent urban, industrial, and green space areas. In addition, the slough is crossed by Interstate 5 and Interstate 205. The lower 13.68 kilometers are tidally influenced.

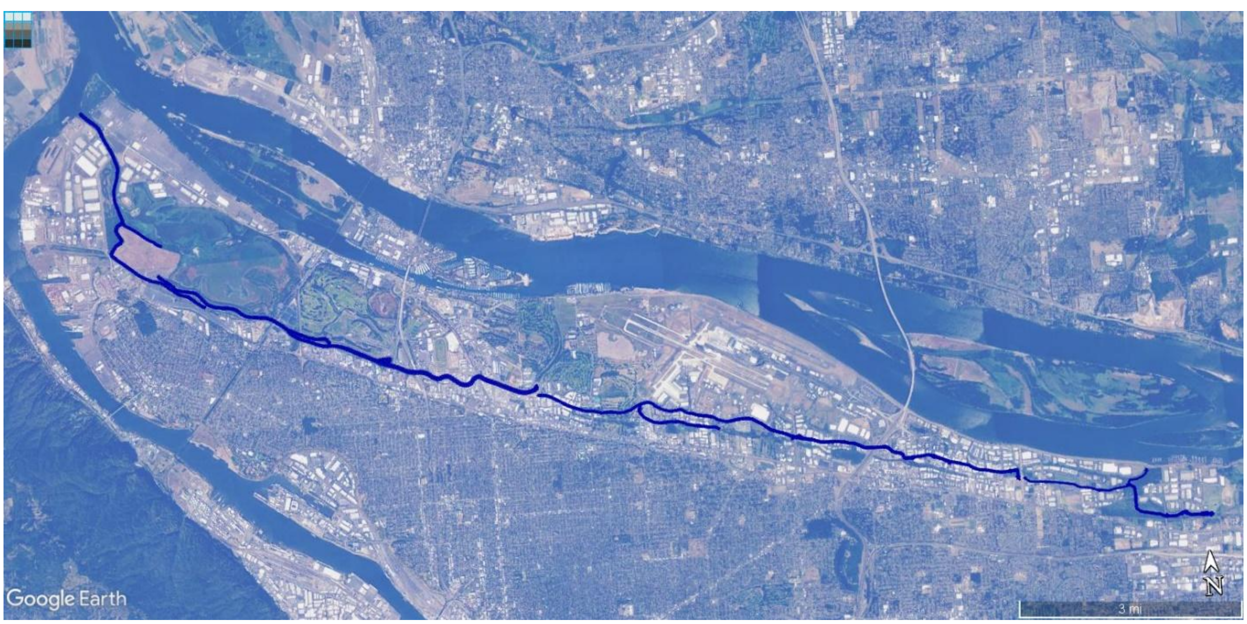

Figure 1. Columbia Slough extent of sampling area.

Slough Surveys

We employed an 1199CI HD Humminbird side imaging system set to obtain continuous sonar data. The sonar transducer was positioned on the bow of a small, aluminum jon boat via a custom mount and set at an operating frequency of 455 kHz. The side beam range was set relative to channel width but never extended beyond 35 meters. Data were recorded while maintaining a mid-channel position at approximately 8.0 km/h.

Habitat Summary

Data were downloaded using SonarTRX version 17.1 and visually displayed using Google Earth Pro. Depth and width measurements were taken at every tenth sonar transect (Figure 2).

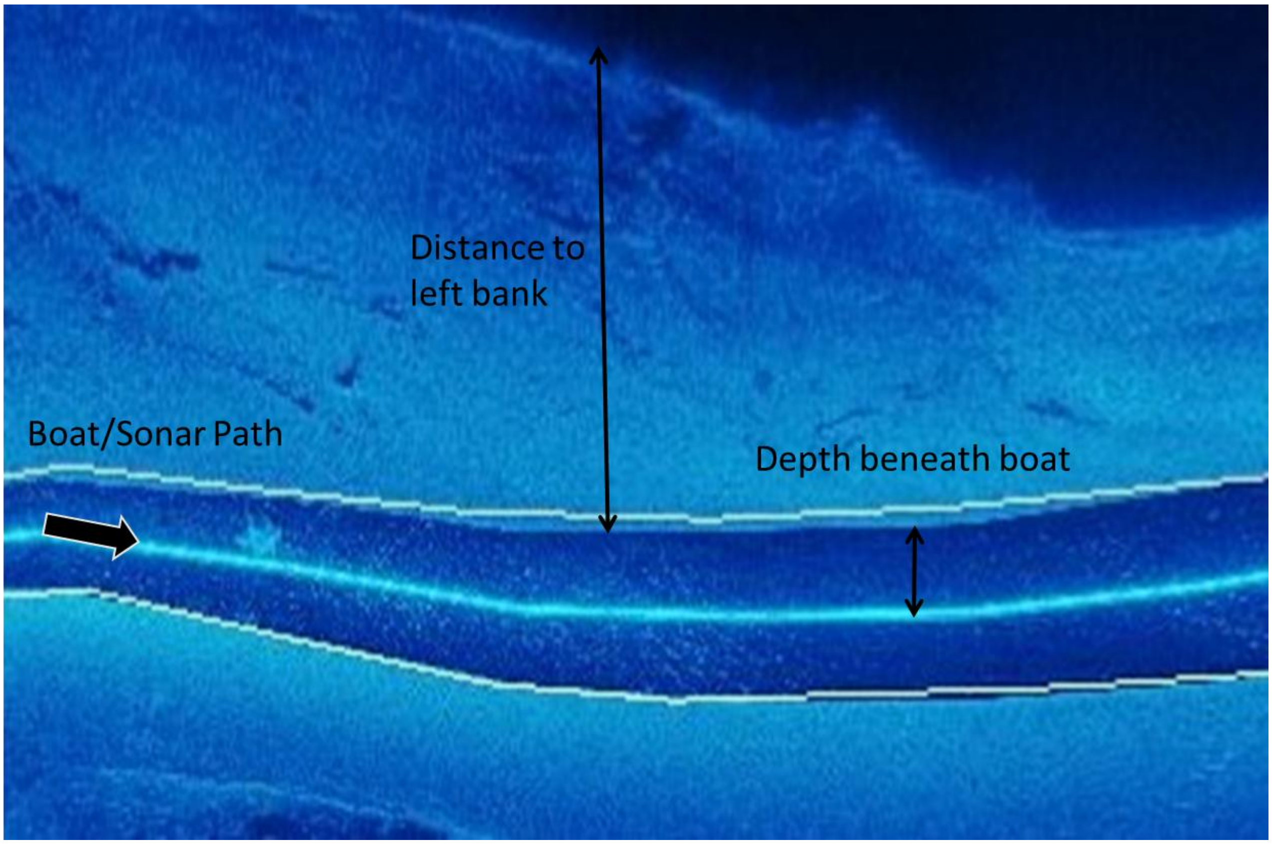

Figure 2. Example of depth and width measurement.

Channel designations and criteria for wood pieces were derived from Moore et al. (2019). Pieces of wood ≥3 meters in length and ≥0.15 meters in diameter were counted and summarized for each reach. In addition, root wads <3 meters in length but ≥0.15 meters in diameter were also counted and summarized. Wood jams were defined as containing ≥5 countable pieces that were touching. We used wood diameter (d) and length (L) to calculate wood volume:

$$V = \pi \left(\frac{d}{2}\right)^2 \times L$$

Substrate (non-silt/mud) and artificial structures (riprap bank, tires, bridge abutments, etc.) were measured (m^2) and calculated as a percent of the sampled area. Differentiation between "natural" and "artificial" rock was based on professional judgement. We looked at proximity to artificial structures and channel placement. In addition, individual structure types were summarized within each reach and channel type in order to give a sense of observation amount (e.g. total number of bridge abutment observations in the Reach 1 primary channel).

Results

We surveyed just over 35 km of slough habitat including primary and tributary channels, a secondary channel and an alcove. The primary channel in Reach 1 was the longest surveyed channel (13.68 km) and Reach 7 was the shortest channel (0.56 km). The average width ranged from 51.49 m (Reach 1, primary channel) to 10.61 (Reach 4, primary channel) (Table 1). The primary channel for Reach 1 had the deepest average depth (2.48 m) and the deepest maximum depth recorded (6.01 m). Reach 6 had the shallowest overall average depth (0.46 m), while Reach 4 had the shallowest recorded depth (0.16 m).

Table 1. Summary of channel dimensions recorded and measured from May 2019 sonar readings in the Columbia Slough.

Reach Number	Channel Type	Length (km)	Avg. Width (m)	Max Depth (m)	Min Depth (m)	Avg Depth (m)
1	Primary	13.68	51.49	6.01	1.08	2.48
1	Secondary	0.95	48.06	1.67	1.20	1.39
1	Alcove	1.42	44.18	1.81	0.82	1.11
2	Tributary	0.95	26.20	2.39	1.85	2.15
3	Primary	2.24	26.94	2.09	0.34	1.20
4	Primary	8.92	10.61	1.82	0.16	0.48
5	Tributary	2.01	28.17	1.38	0.37	0.82
6	Primary	4.61	12.42	1.06	0.18	0.46
7	Tributary	0.56	17.61	1.14	0.64	0.91

The primary channel in Reach 1 had eight individual key pieces of wood, the most observed across all 7 reaches (≥12m in length and 0.60m in diameter), while Reach 2 had the highest frequency of key pieces at 0.31 key pieces/100 meters (Table 2). The majority of reaches contained no key pieces. The number of wood jams was highest in the primary channel of Reach 1 with the secondary channels in Reaches 1 and 2 having the highest number of jams/100 meters. Several reaches contained no wood jams.

Table 2. Summary of large wood recorded and measured from May 2019 sonar readings in the Columbia Slough.

Reach Number	Channel Type	Key LWD Pieces	Key LWD per 100m	# LWD Jams	LWD Jams per 100m	LWD Vol(m^3) per 100m
1	Primary	8	0.05	35	0.25	9.98
1	Secondary	0	0.00	19	1.99	72.92
1	Alcove	0	0.00	12	0.83	15.89
2	Tributary	3	0.31	19	1.99	60.44
3	Primary	1	0.04	0	0.00	0.95
4	Primary	0	0.00	10	0.11	0.87
5	Tributary	2	0.09	11	0.54	13.60
6	Primary	0	0.00	0	0.00	0.01
7	Tributary	0	0.00	0	0.00	0.14

Substrate composition and artificial structures were quantified by area and presented as a percent of the slough bottom captured by sonar. A dearth of naturally occurring rocky substrate was observed throughout the slough with the primary channel in Reach 1 containing the most with 0.58%. Many reaches contained no natural rocky substrate (Table 3). The majority of these substrate types were a mixture of sand, gravel, and cobble, but patches of both bedrock and boulders were encountered (Appendix A). Although not evenly distributed, artificial structures (e.g. riprap bank, tires, bridge abutments) were observed across all reaches. The secondary channel in Reach 1 contained the highest percentage of artificial structure (8.36%) while the alcove in Reach 1 had the lowest observed (<0.01%).

Table 3. Summary of rock substrate and artificial structures recorded and measured from May 2019 sonar readings in the Columbia Slough.

Reach Number	Channel Type	Natural Rock (m^2)	% Natural Rock	Artificial Structures (m^2)	% Artificial Structure
1	Primary	4111.68	0.58	35777.32	5.07
1	Secondary	0.00	0.00	3833.64	8.36
1	Alcove	0.00	0.00	4.69	0.01
2	Tributary	5.33	0.02	519.68	2.08
3	Primary	50.40	0.08	1020.65	1.68
4	Primary	185.60	0.19	960.26	1.01
5	Tributary	110.88	0.19	2077.60	3.65
6	Primary	0.00	0.00	567.40	0.98
7	Tributary	0.00	0.00	305.32	3.05

Discussion

We chose to compile substrate types into a single category, "Natural Substrate" due to both the scarcity of substrate (sand, gravel, cobble, boulder, and bedrock) across the entire sampling area and the difficulty in distinguishing individual substrate types. Boulders are likely not a naturally occurring substrate feature in the Columbia Slough, but in instances when boulders were observed without artificial structure (ex. riprap bank) in the immediate vicinity, we categorized them as a natural feature. It can be assumed from the data that all other substrate in the slough was mud/silt. This would suggest that across all sampled reaches and channels mud/silt comprises >99% of the natural substrate. Results from the sonar images indicate Reach 1 and Reach 2 contain the greatest volume of wood, jams, and number of key pieces.

Recent analyses from the Aquatic Inventories Project have used reference values derived from Miller et al. (2016) to provide comparative context for evaluating large wood metrics when sampling wadeable streams (<4th order). These reference values are not appropriate for use in non-wadeable, slow-moving riverine environments such as the Columbia Slough, and little is available given the anthropomorphic influence of similar habitats across the Pacific Northwest. These influences have been noticeable throughout the Columbia River estuary, including the Columbia Slough and have been particularly detrimental to rearing juvenile salmonids due to a loss of historical habitat (Bottom et al. 2005 and ODFW 2010). Finding a way to characterize the natural flow regime influencing the composition and distribution of habitats in large regulated rivers is a major obstacle to overcome if we want to have the ability to use reference values for comparative context.

While the use of a side scan sonar provided an efficient and effective method for describing channel dimensions and different structure types, there was no shortage of challenges (Appendix B). Turbidity throughout the slough was one of the primary reasons we employed sonar, but this also made ocular calibration nearly impossible. In addition, the sonar depends on consistent speed (~8 km/hour) and direction for image clarity. Vast sections of the slough had dense aquatic vegetation that not only slowed boat speed causing image distortion but was also dense enough in places to cause the beam transmission to only return vegetative cover. In reach sections with dense aquatic vegetation it is highly likely both natural and artificial structure (wood, rock, etc.) were not captured. Due to our inability to conduct any ocular calibration along with vegetation bias, data should not be interpreted as absolute values but rather as a general description of the habitat and results can be used as a tool to help prioritize habitat actions for the Columbia Slough. Future sonar sampling should include physical measurement of aquatic vegetation cover when distortion of screen images is observed.

Future application of non-wadeable methods and side scan sonar should also include considerable calibration effort. This would involve spatially representative cross section measurement in habitats such as the Columbia Slough and field methods described in Moore et al. (2019) if sampling complex or technical flow influence (ex. rapids and channel sinuosity). This will be particularly important if sampling objectives include describing individual substrate classes. In addition, calibration should account for some quantitative measure of the number of pieces of wood that meet minimum size requirements. Consideration should also be given to an alternate approach for collecting depth measurements. Currently, depths are collected by the sonar under the direct path of the boat. While this accounts for a thalweg depth profile, it likely misses points of maximum depth and certainly does not allow for an adequate depth profile associated with bank habitat.

Acknowledgments

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References

Bottom, D.L., C.A. Simenstad, J. Burke, A.M. Baptista, D.A. Jay, K.K. Jones, E. Casillas, and M.H. Schiewe. 2005. Salmon at a river's end: the role of the estuary in the decline and recovery of Columbia River salmon. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-68, 246 p.

Adam J. Kaeser and Thomas L. Litts. 2010. A Novel Technique for Mapping Habitat in Navigable Streams Using Low-cost Side Scan Sonar, Fisheries, 35:4, 163-174, DOI: 10.1577/1548-8446-35.4.163

Miller, S., P. Eldred, A. Muldoon, K. Anlauf-Dunn, C. Stein, S. Hubler, L. Merrick, N. Haxton, C. Larson, A. Rehn, P. Ode, and J. Vander Laan. 2016. A large-scale, multiagency approach to defining a reference network for Pacific Northwest Streams. Environmental Management, 58, 6: 1091-1104.

Moore, K.M.S., K.K. Jones, and J.M. Dambacher. 2007. Methods for stream habitat surveys. Oregon Department of Fish and Wildlife, Corvallis, Oregon.

Oregon Department of Fish and Wildlife. 2010. Lower Columbia River Conservation & Recovery Plan for Oregon Populations of Salmon & Steelhead. Oregon Department of Fish and Wildlife, Salem, Oregon.

Columbia Slough

Appendix A

Summary of Comments

Oregon Department of Fish and Wildlife

Aquatic Inventories Project

Reach #	Channel Type	Structure	Structure Type	Count
1	Primary	rock	Bedrock	4
1	Primary	rock	boulder	4
1	Primary	rock	gravel/cobble/boulder	7
1	Primary	rock	long band of bedrock	1
1	Primary	rock	sand/gravel/cobble	3
2	Tributary	rock	boulder	4
3	Primary	rock	boulders	1
3	Primary	rock	gravel/cobble/boulder	1
4	Primary	rock	Bedrock	1
4	Primary	rock	boulder	1
4	Primary	rock	gravel/cobble/boulder	5
4	Primary	rock	sand/gravel/cobble	1
5	Tributary	rock	gravel/cobble/boulder	3
1	Primary	artificial	Barrel	5
1	Primary	artificial	boat	3
1	Primary	artificial	bridge abutment	26
1	Primary	artificial	car	2
1	Primary	artificial	concrete	5
1	Primary	artificial	culvert	1
1	Primary	artificial	Inflow/outflow control pipe	3
1	Primary	artificial	old fencepost	18
1	Primary	artificial	piling	11
1	Primary	artificial	pilings clustered together	1
1	Primary	artificial	pipe	4
1	Primary	artificial	railroad bridge abutment	8
1	Primary	artificial	riprap bank	29
1	Primary	artificial	shopping cart	7
1	Primary	artificial	tire	1
1	Primary	artificial	tower	1
1	Primary	artificial	unknown structure	66
1	Primary	artificial	water intake	3
1	Primary	artificial	water outflow	1
1	Secondary	artificial	bridge abutment	2
1	Secondary	artificial	pilings clustered together	1
1	Secondary	artificial	riprap bank	3
1	Secondary	artificial	unknown structure	2
1	Alcove	artificial	piling	12
1	Alcove	artificial	tire	1

Reach #	Channel Type	Structure	Structure Type	Count
1	Alcove	artificial	unknown structure	1
2	Tributary	artificial	riprap bank	7
3	Primary	artificial	bridge abutment	2
3	Primary	artificial	concrete bank	1
3	Primary	artificial	riprap bank	11
3	Primary	artificial	unknown structure	2
4	Primary	artificial	Barrel	1
4	Primary	artificial	concrete bank	1
4	Primary	artificial	concrete inflow	2
4	Primary	artificial	Inflow/outflow control pipe	1
4	Primary	artificial	riprap bank	18
4	Primary	artificial	unknown structure	25
5	Tributary	artificial	riprap bank	4
5	Tributary	artificial	tires	1
5	Tributary	artificial	unknown structure	2
6	Primary	artificial	bridge abutment	1
6	Primary	artificial	riprap bank	17
6	Primary	artificial	tire	4
6	Primary	artificial	unknown structure	13
7	Tributary	artificial	riprap bank	1
7	Tributary	artificial	unknown structure	1

Columbia Slough
Appendix B

Guide to Viewing and Interpreting Sonar Images in the Columbia Slough, Oregon

Eric Bailey and Emily Loose

Oregon Department of Fish and Wildlife

Aquatic Inventories Project

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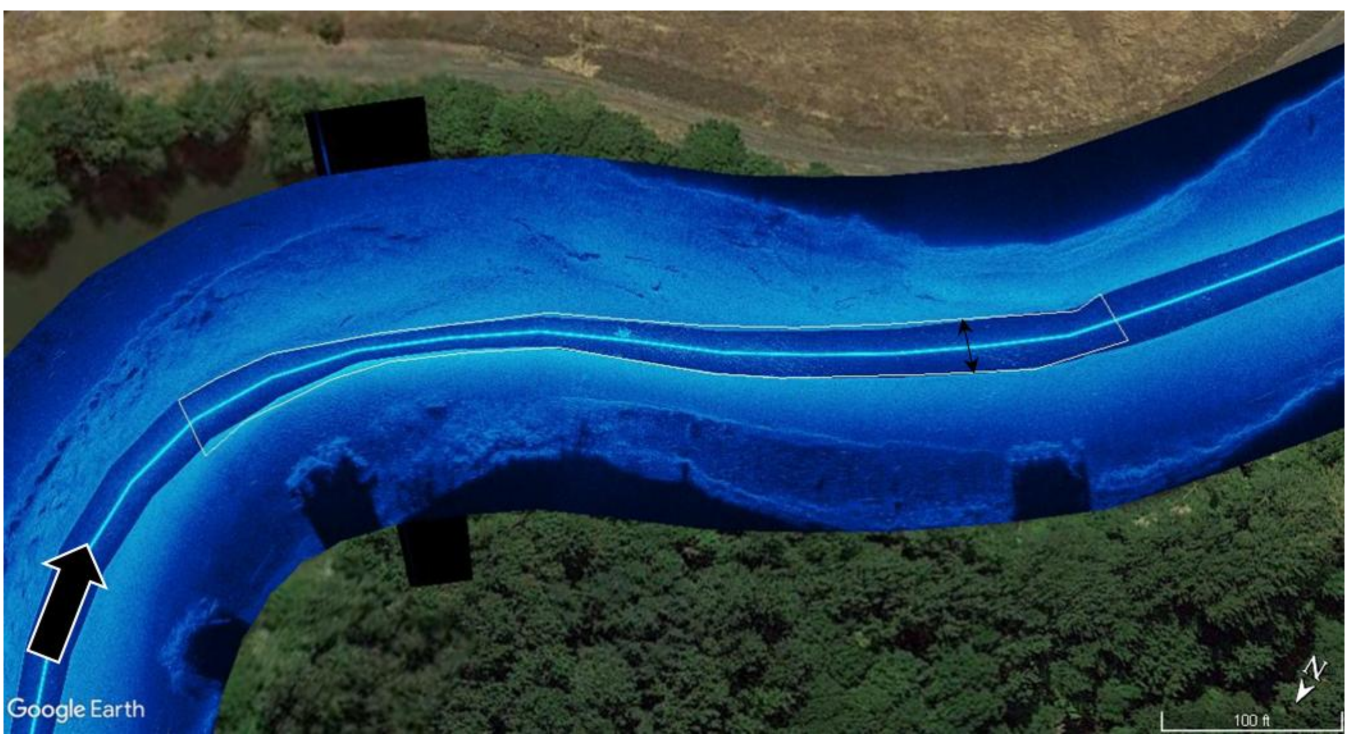
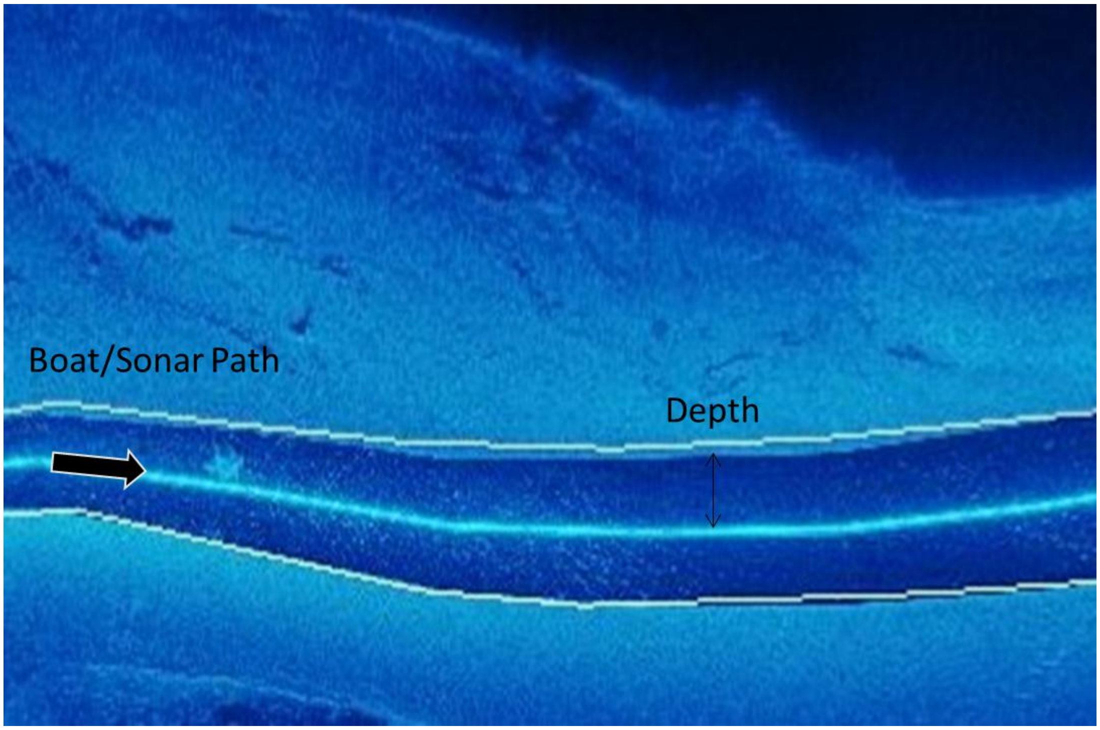
EXTENT OF SAMPLING

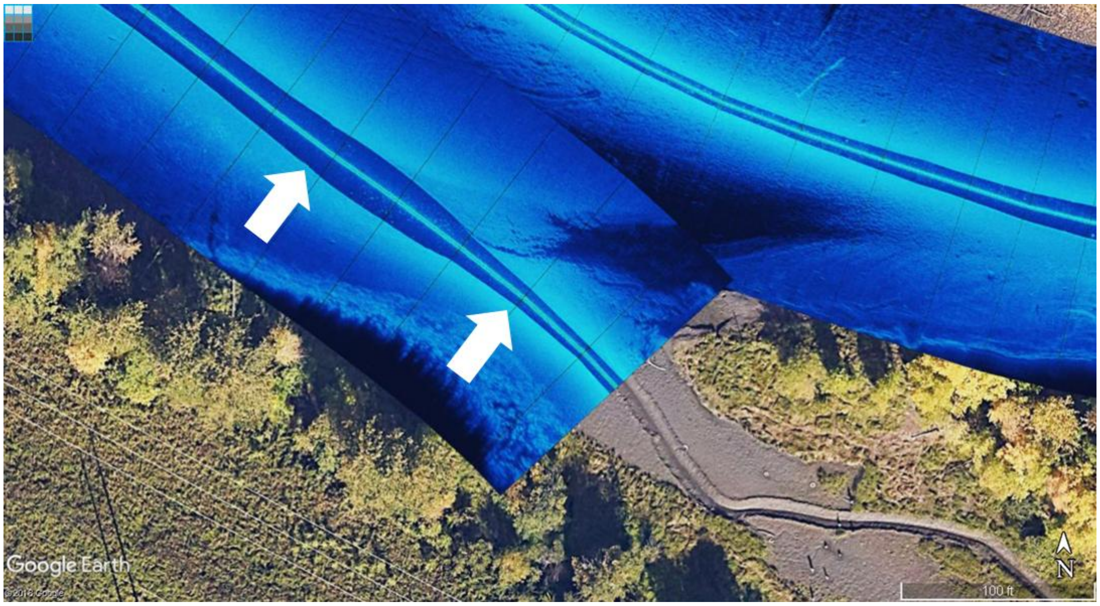
Figure 1. This overview of the Columbia Slough shows the extent of the sonar imaging and reach locations for the spring of 2019.

TIPS FOR READING SONAR IMAGES



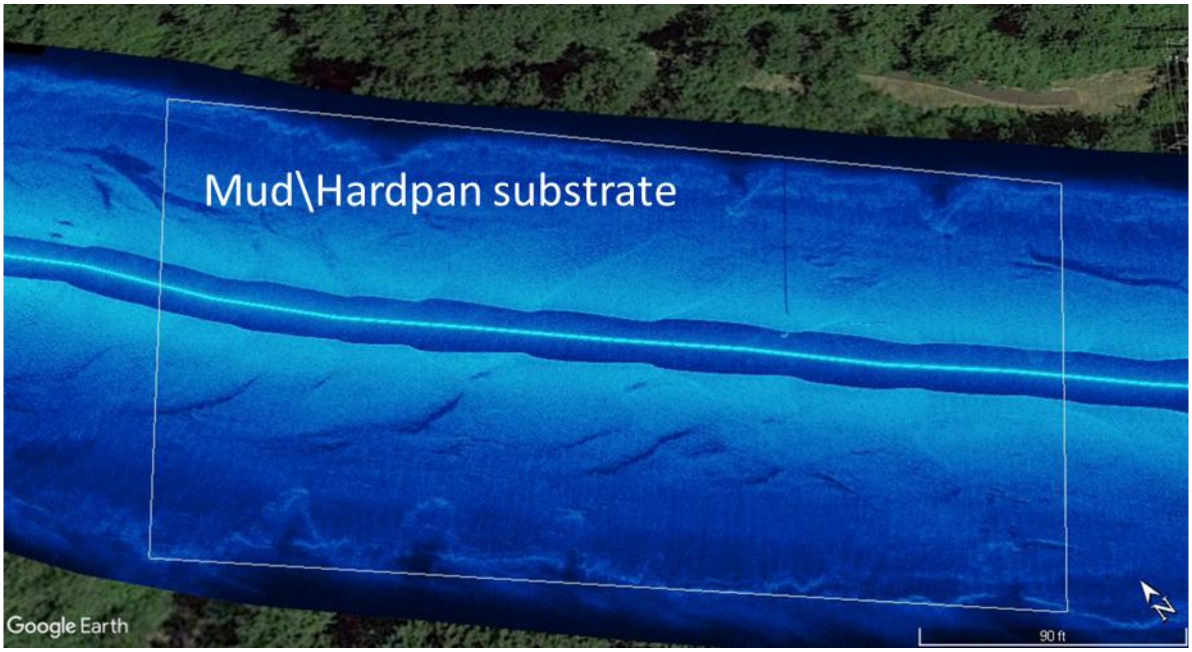
In the image above, the highlighted area shows the water column and the path of the boat in the Columbia Slough. The bright blue line running through the center of the image is the sonar/boat path. The dark blue areas on either side of the sonar/boat path, represent the water column with its relative depth of the water beneath the boat. Variations in the width of the water column show variations in the distance to the bottom (depth) as the boat passes over.

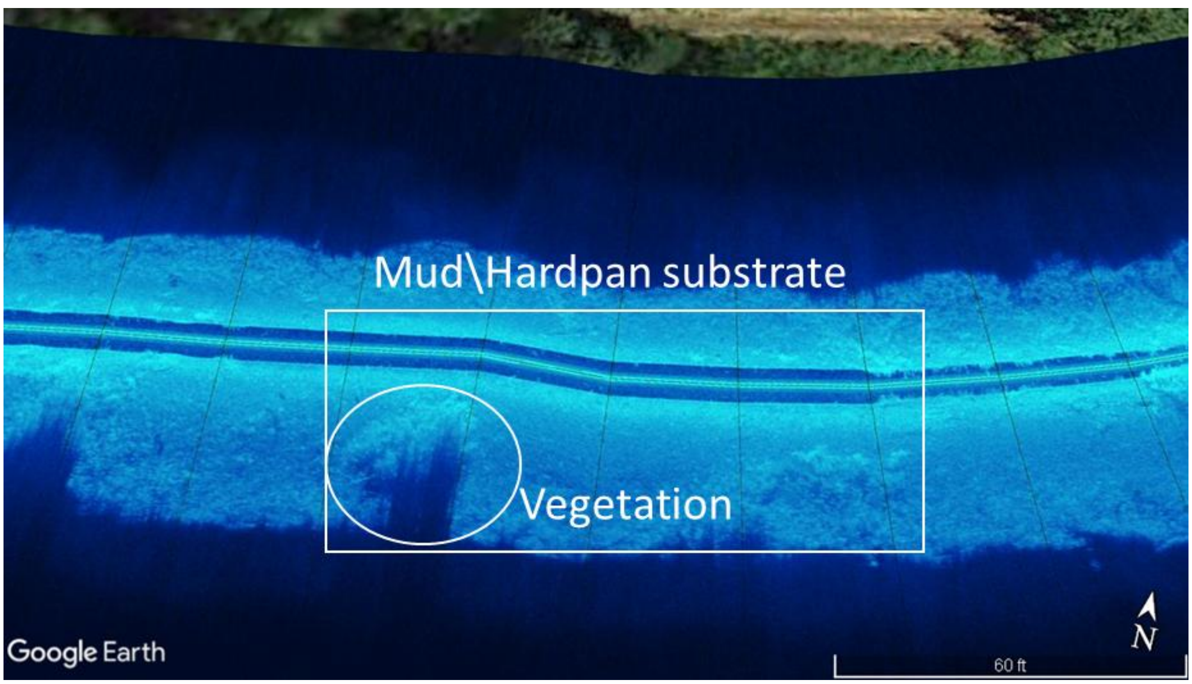




The dark blue area on either side of the centerline in the top image, which represents the water column, narrows rapidly as the water becomes shallow. The bottom sonar image was recorded in May 2019, and the image from Google Earth is from July 2018. The Google Earth image illustrates the absence of water later in the year, and the remaining channel can be seen in the lower right corner of the bottom photo.

Numerous obstacles including large logs, branches, mats of vegetation, and trash impeded the sonar requiring the transponder to be lifted out of the water. The image on the right shows a lack of sonar data where the transponder was lifted out of the water.

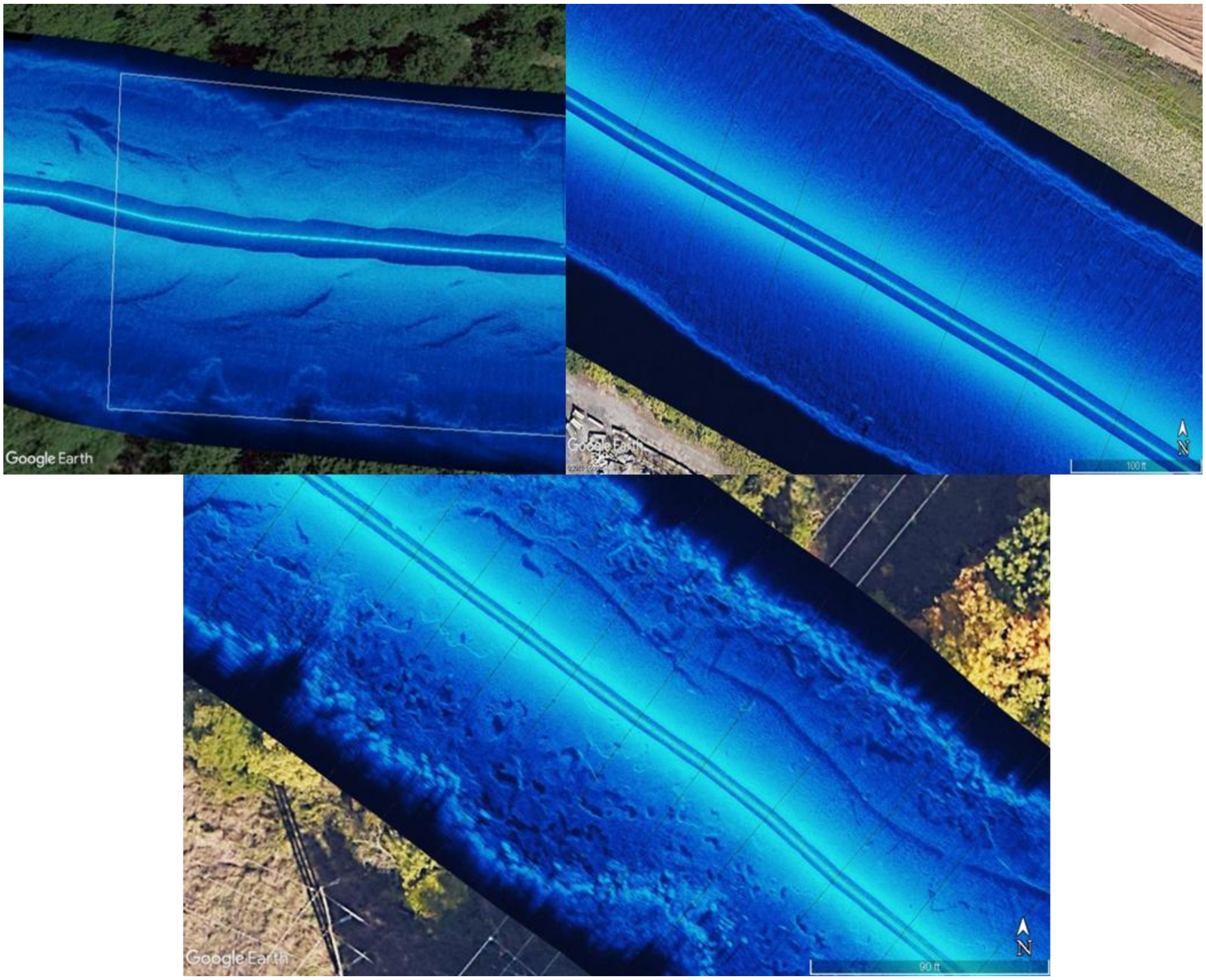




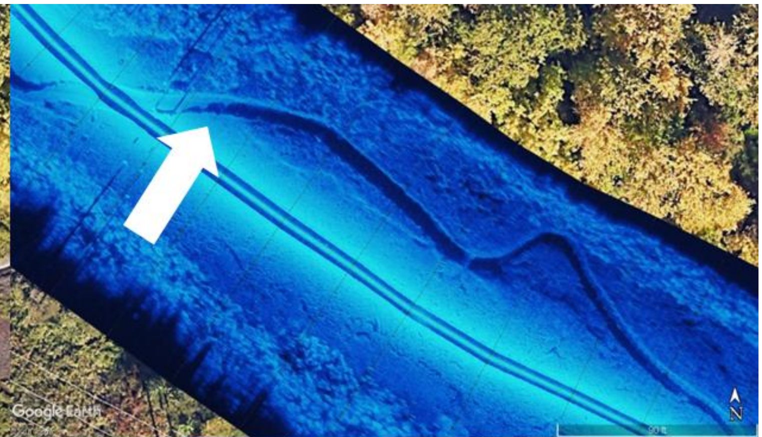
The substrate of the Columbia Slough consists primarily of mud\hardpan throughout the entire length. Concentrations of vegetation are dense and more prolific in the shallow upper reaches of the slough.

REACH 1

Figure 2. Reach 1extended from the mouth of the Columbia Slough to the west side of the Elrod Levee.



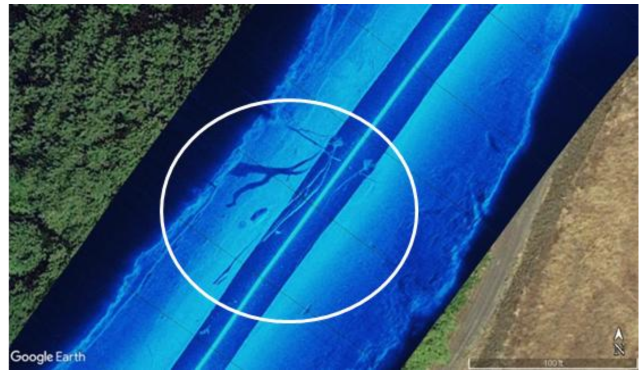
The substrate in Reach 1 consisted primarily of mud and hardpan. The top left photo shows the hardpan substrate on the lower Slough, near where it empties into the Columbia River. The ripple effect seen here is likely related to the tidal influence of the Columbia River. The top right image shows smooth mud substrate, the dominate substrate of the Slough. The bottom photo shows mud with what appears to be burrows.



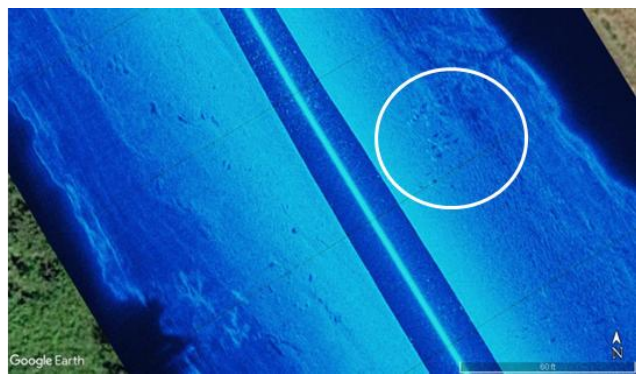
These photos from Reach 1 illustrate some interesting channel bed irregularities. The top left photo shows what appears to be a deep track in the sediment, while the top right image reveals that this is what remains of the water channel at low water. The sonar image was recorded in May 2019, while the image from Google Earth is from July 2018, and illustrates the absence of water later in the year.

The bottom image shows a water input or output nearby, in contrast to the appearance of banks.

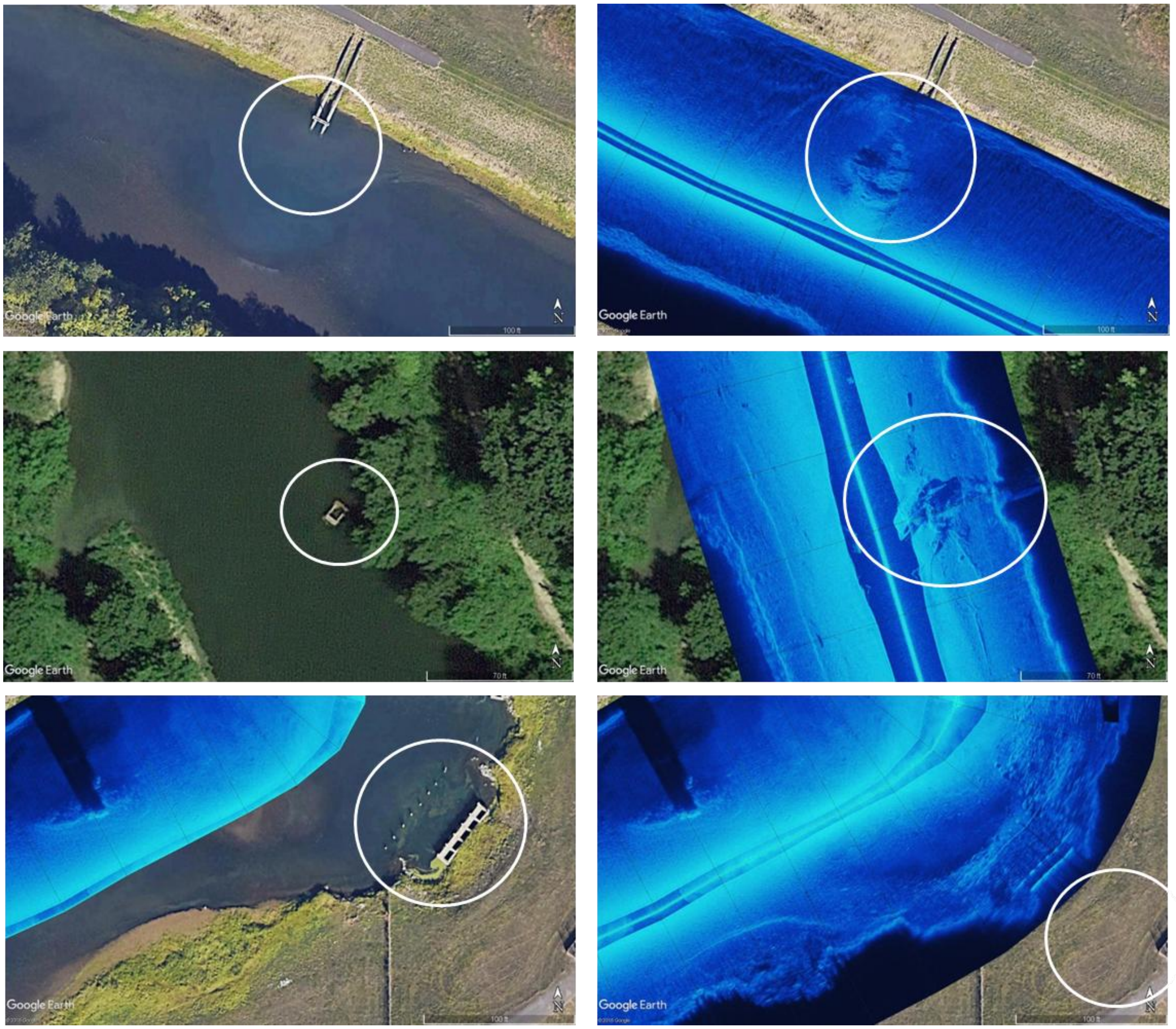
Reach 1 wood observations; wood structures that have been placed into the Slough as well as trees and branches that have fallen into the waterway. Various types of wood can be seen in the above images with and without the sonar overlay. The top two sets of images show wood structures that have been placed in the Slough, while the bottom set of images shows a fallen tree.



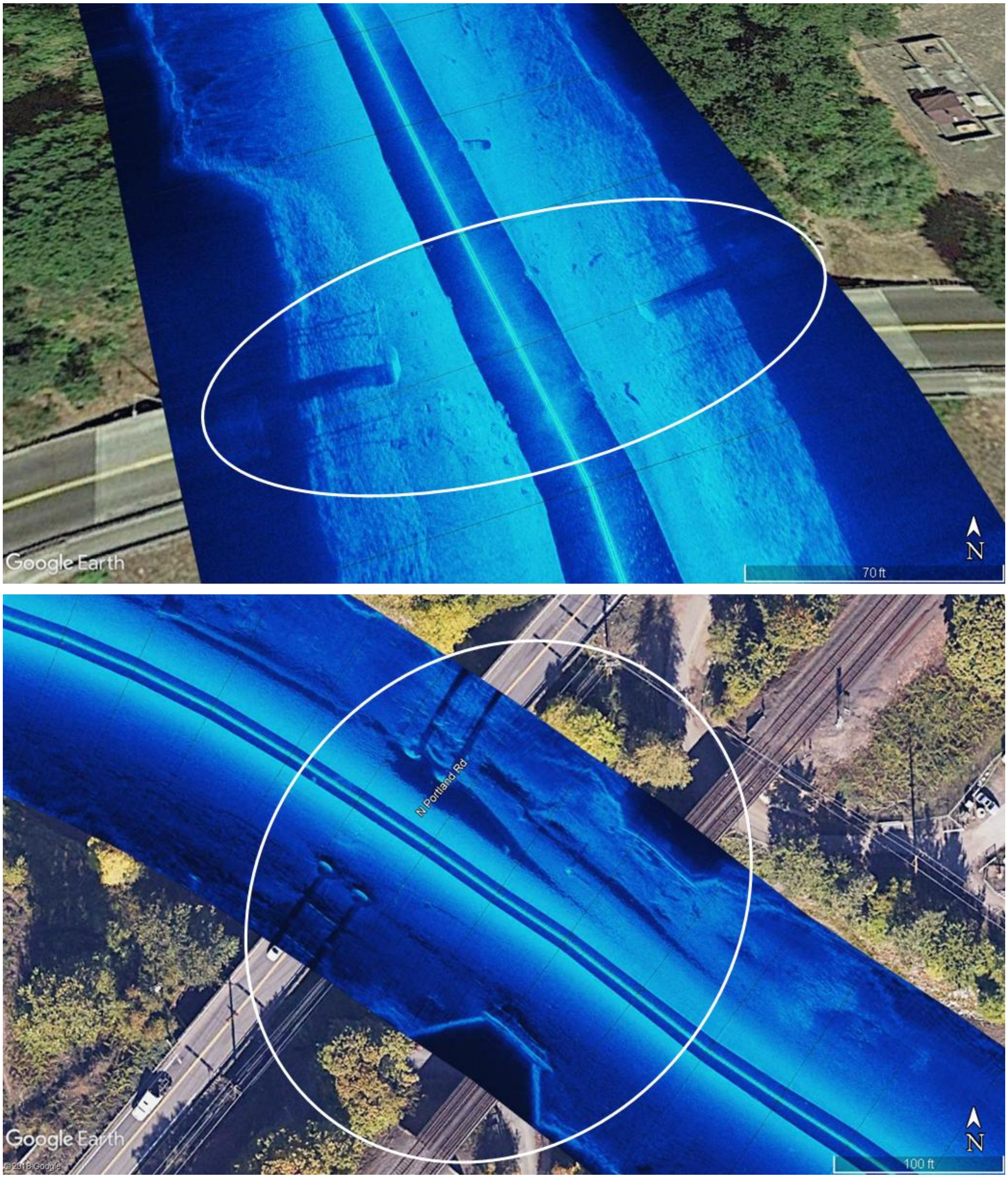
Tree branches, Reach 1: The shadow behind the image on the left shows that the branch extends up into the water column on the left hand side of the sonar transducer, while the image on the right shows the branches extending up into the water column directly under the transducer.



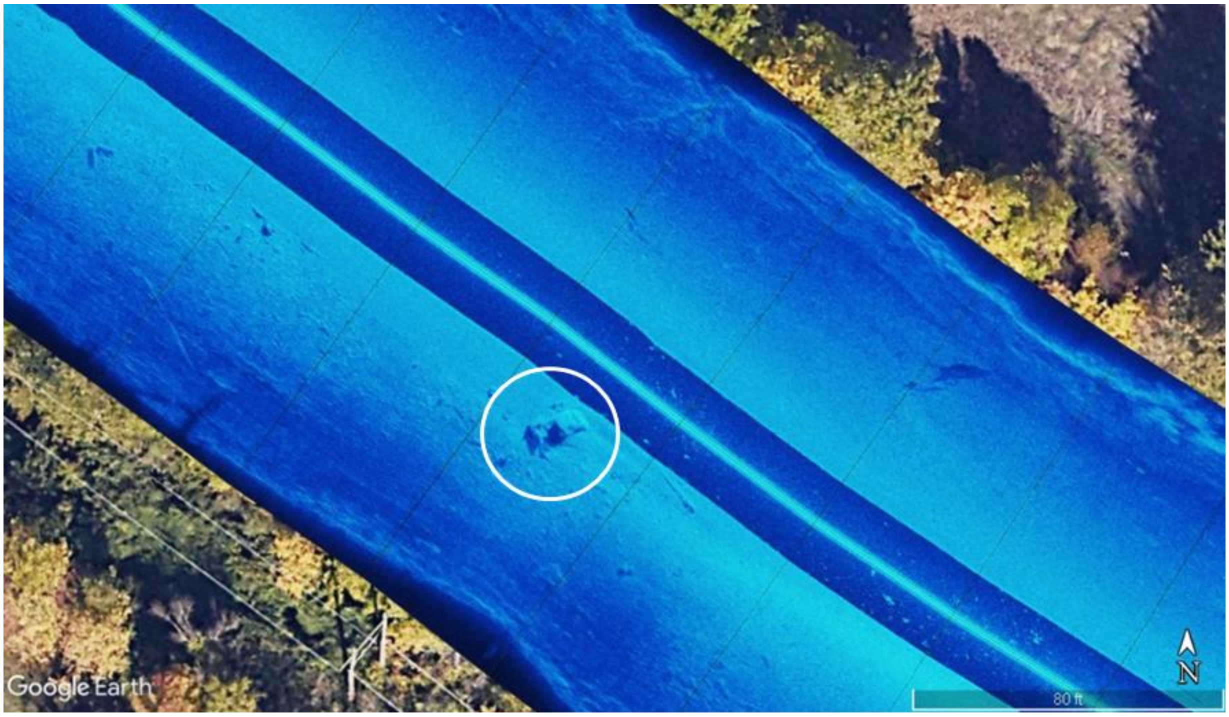
Reach 1 fish observations; the two images above show fish in the water column. These are likely carp, as they are fairly large, and many carp were seen in this section of the Slough.

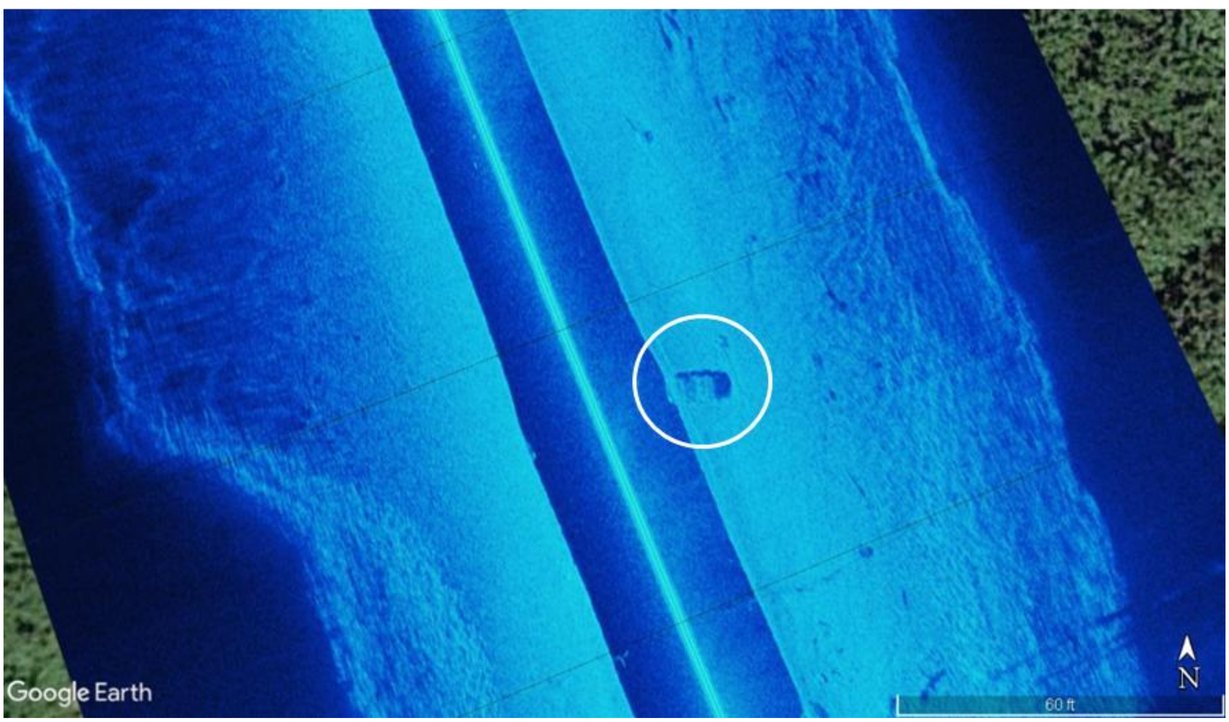


Reach 1 water flow; various types of structures affecting water flow can be seen in Reach 1 with and without sonar. The sonar overlay in the top set of images shows how flow from these pipes has affected the sediment. The sonar overlay in the middle set of images shows how this structure extends up into the water column. The bottom set of images shows an above and underwater view of the structure at the west side of the Elrod Levee.



Reach 1 bridge structure; the various types of supporting foundations for bridges can be seen in Reach 1. These include North Lombard Street near North Kelley Point Park Road (top), and a bridge on North Portland Road and its neighboring railroad bridge (bottom).





Reach 1 also contained some man-made objects that were unanticipated, such as these two objects that appear to be cars.

REACH 2

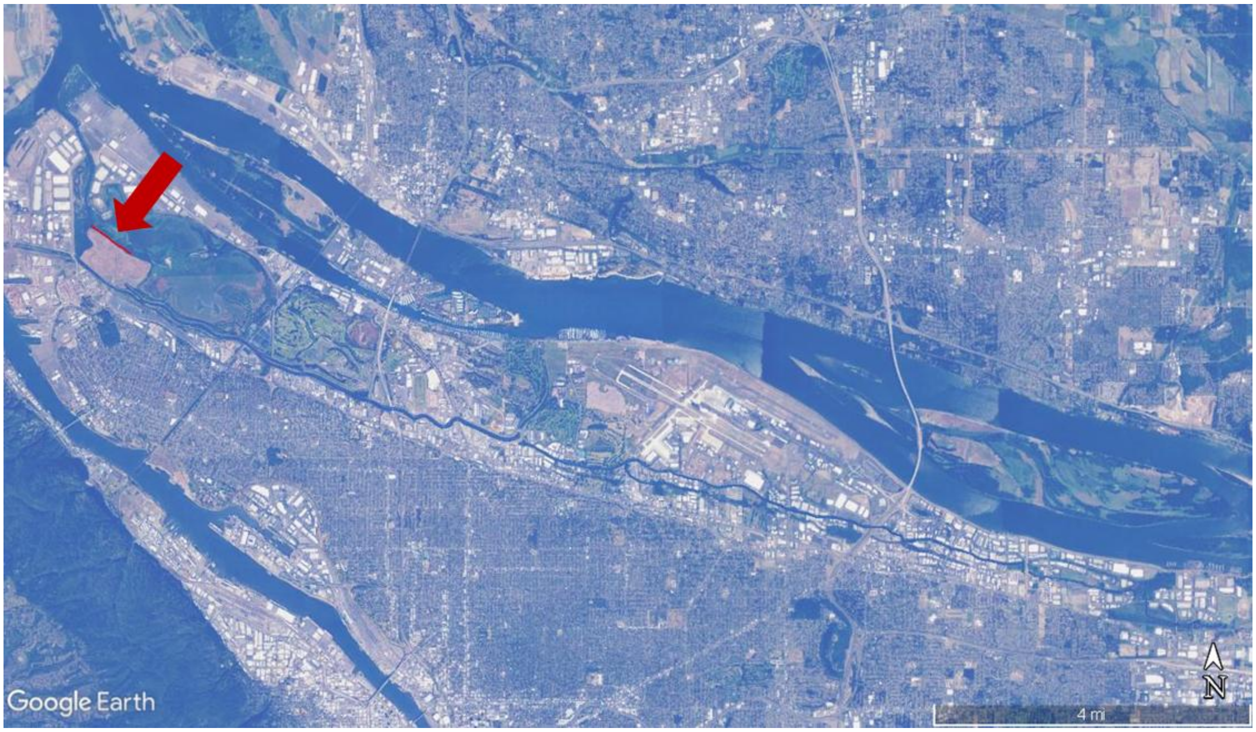
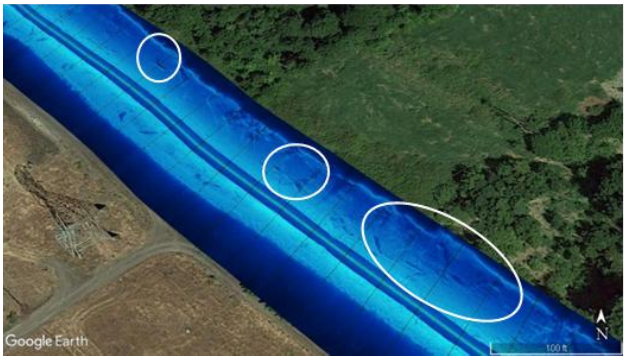
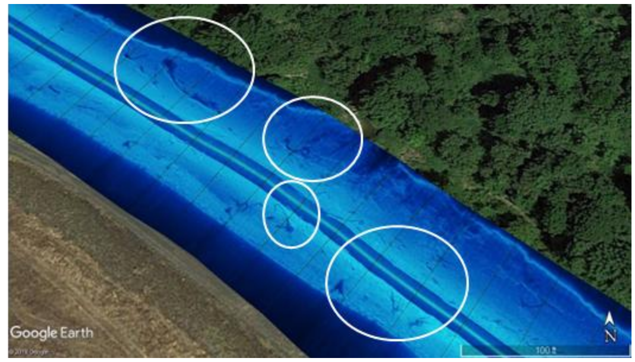


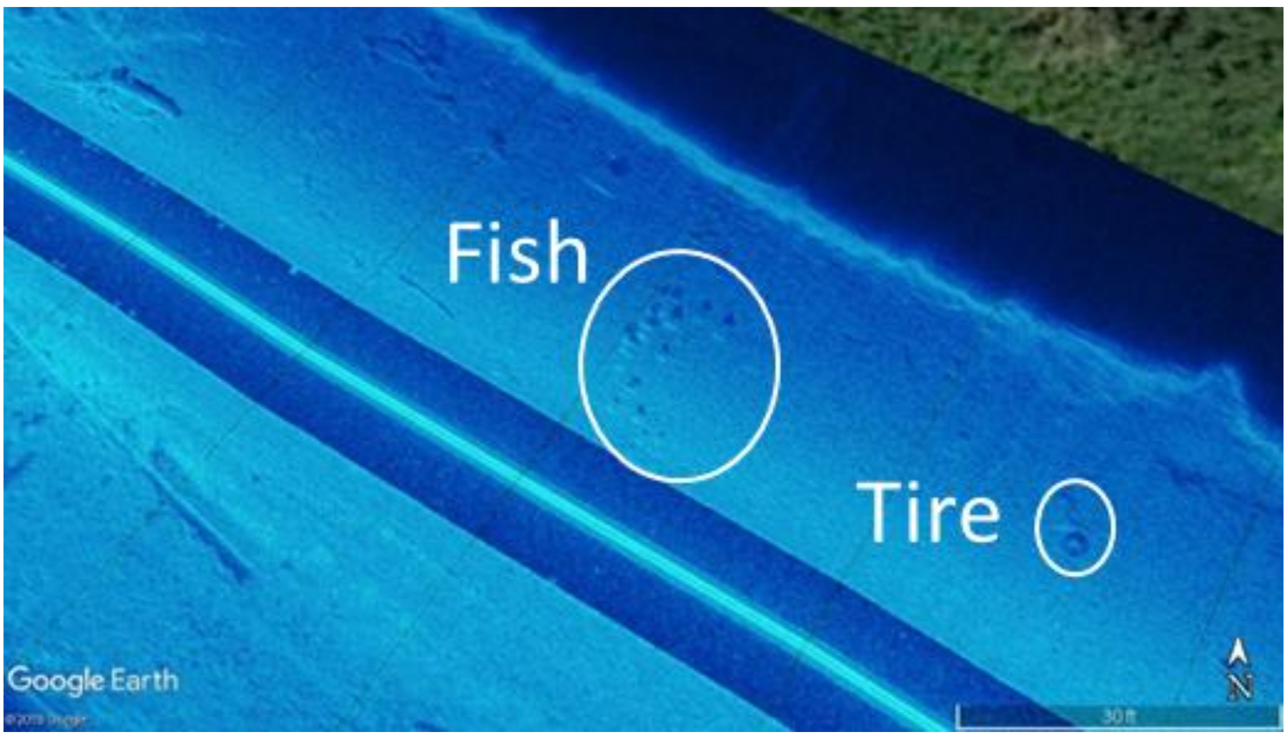
Figure 3. Reach 2, St. John's Landfill side channel.

The substrate in Reach 2 consisted of mud \hardpan throughout the entirety of the side channel. Also of note are many pieces of large wood. Several schools of fish were observed with the sonar as well.





Highlighted above are a number of large wood pieces seen throughout the side channel.



The image above shows a school of fish and a tire.

REACH 3

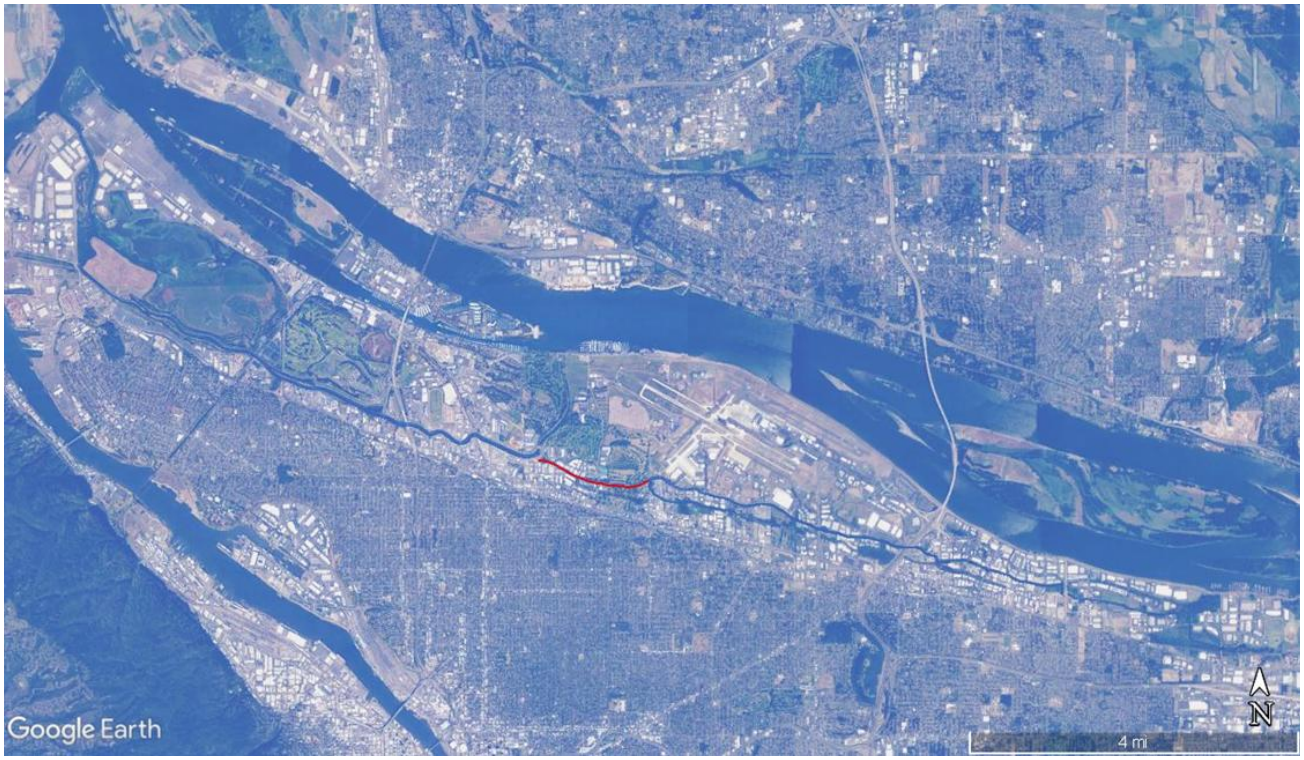
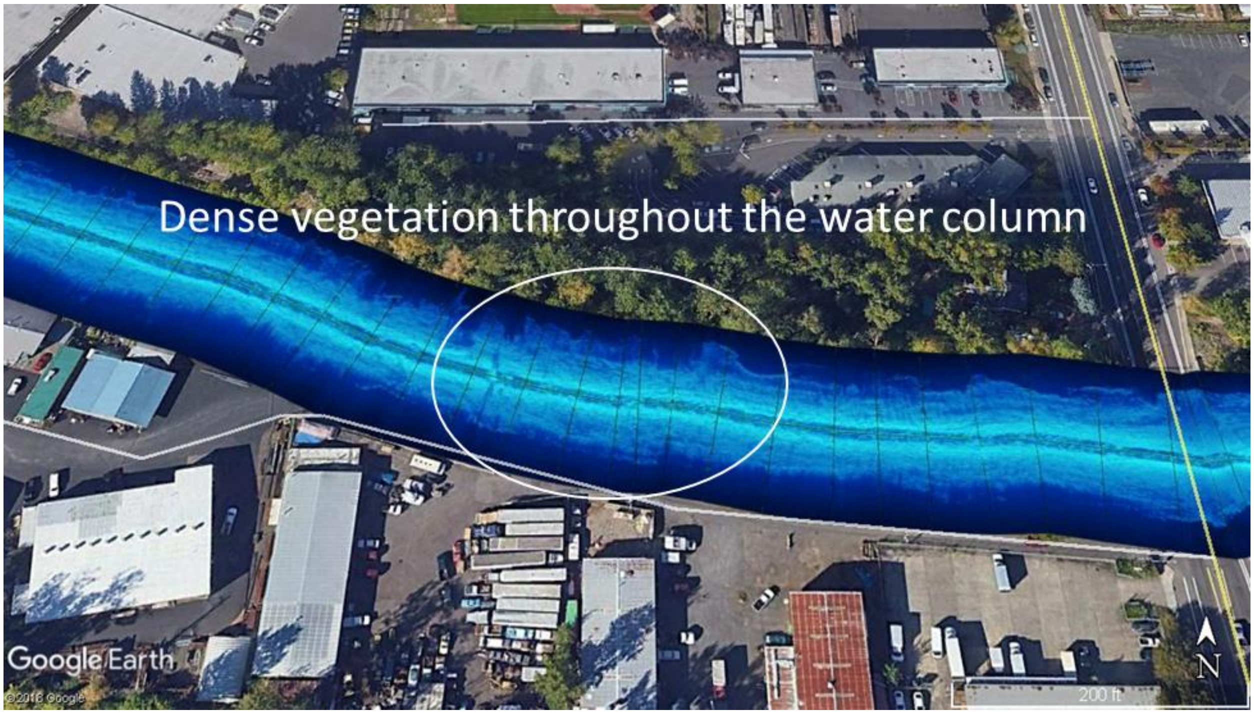


Figure 4. Reach 3 extended from Elrod Levee to the mouth of Whitaker Slough.

While this is an industrial area, the slough had a noticeable riparian.



The substrate in Reach 3 was mud and the water column had dense vegetation. We found very few pieces of submerged wood in this reach.

REACH 4

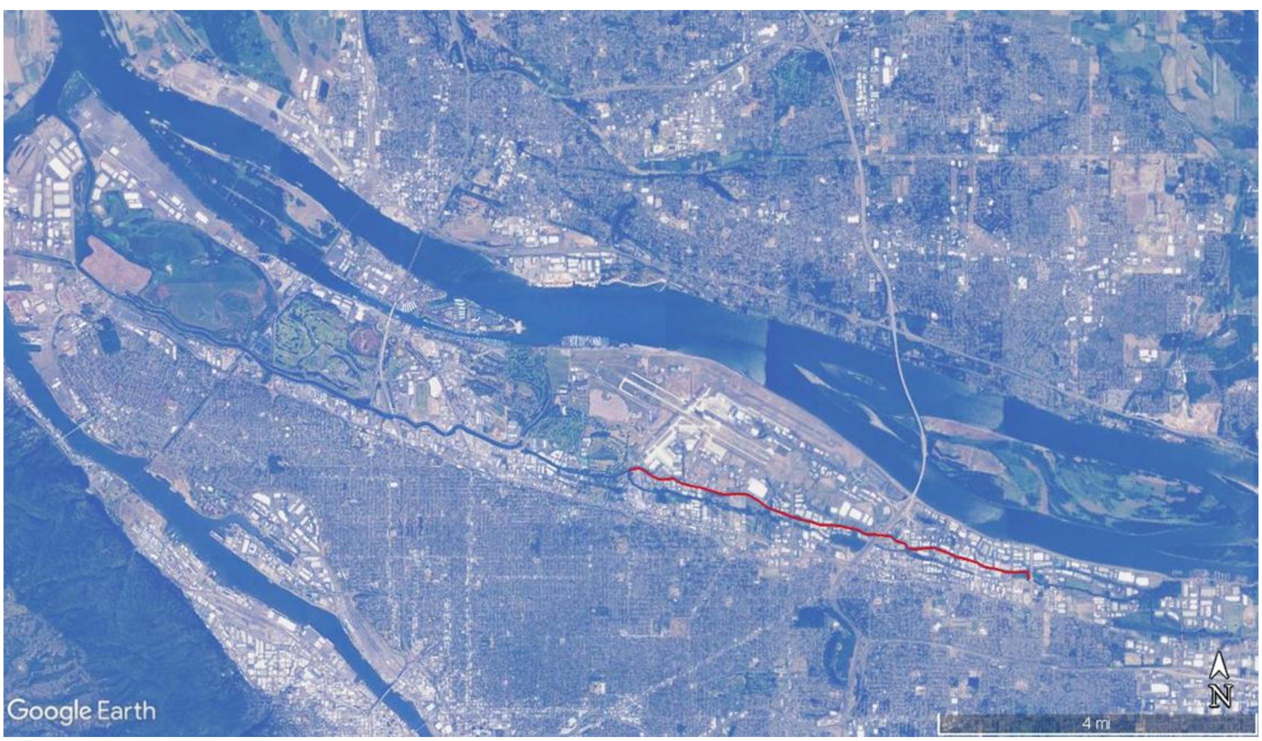
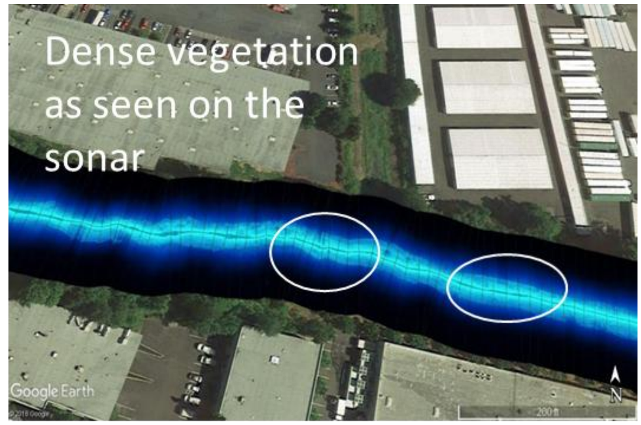
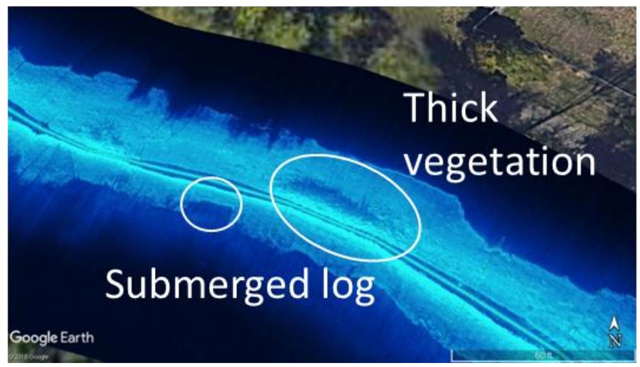


Figure 5. Reach 5 extended from Whitaker Slough to 143rd Avenue Levee.





This section of the slough is narrow and shallow, and heavily inundated with vegetation. The substrate is mud/hardpan throughout. At several locations within this reach the vegetation is so thick that it is nearly impassable. The images above highlight some of the dense vegetation in Reach 4.

REACH 5

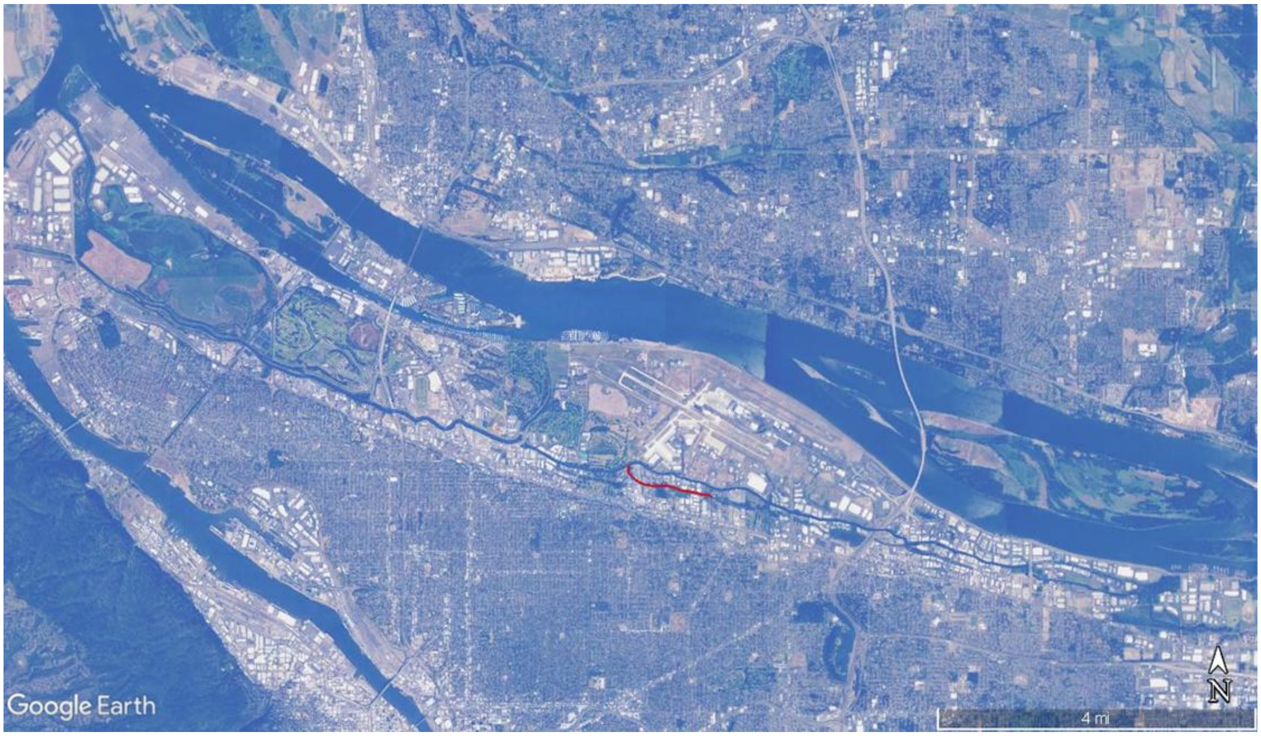


Figure 6. Reach 5, Whitaker Slough.

The above image shows the extent of sampling for Reach 5. We were only able to survey up to 63rd street due to a culvert that made further boat travel impassible.

The substrate of Whitaker Slough is largely composed of mud with very dense vegetation growth throughout. The middle portion of the slough provided a noticeable riparian buffer.

The images above were taken from various points along Whitaker Slough and show mud substrate heavily inundated with vegetation.

REACH 6

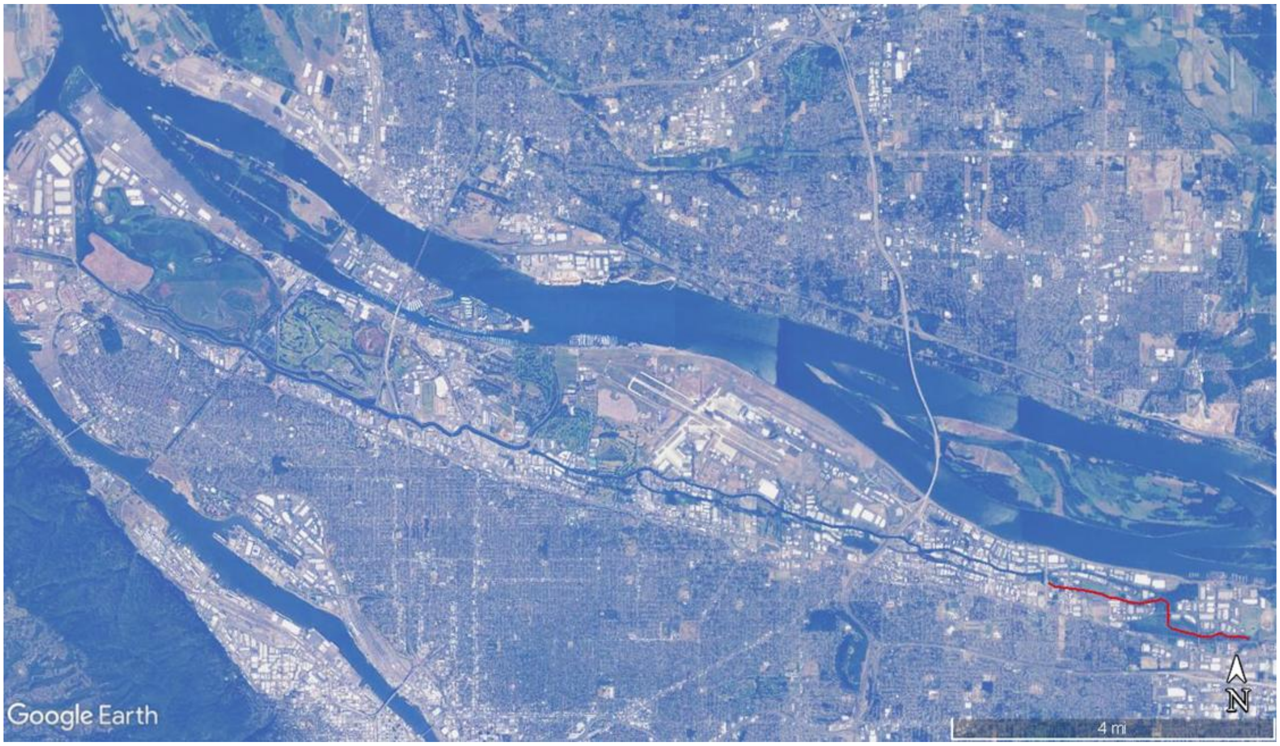
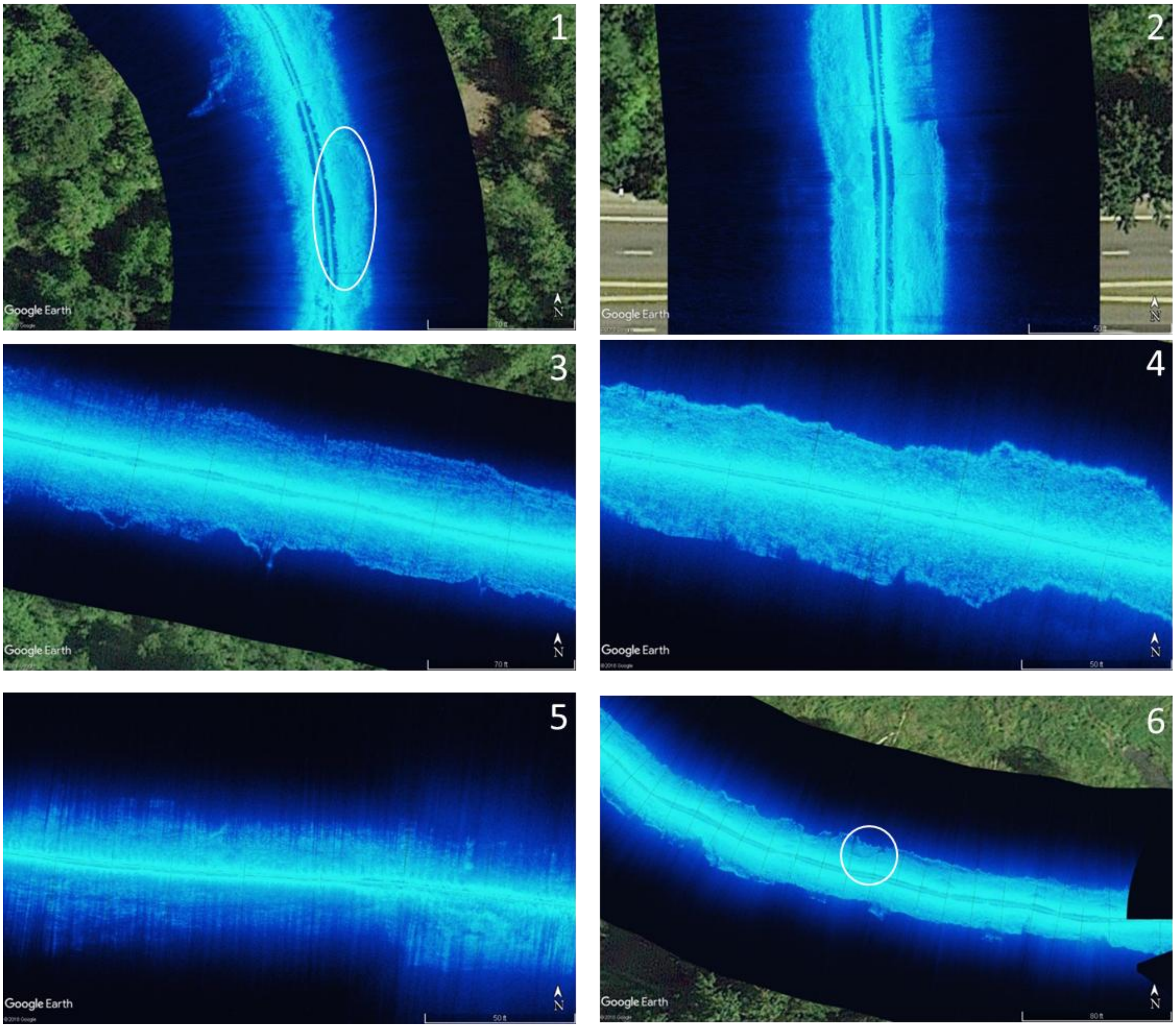
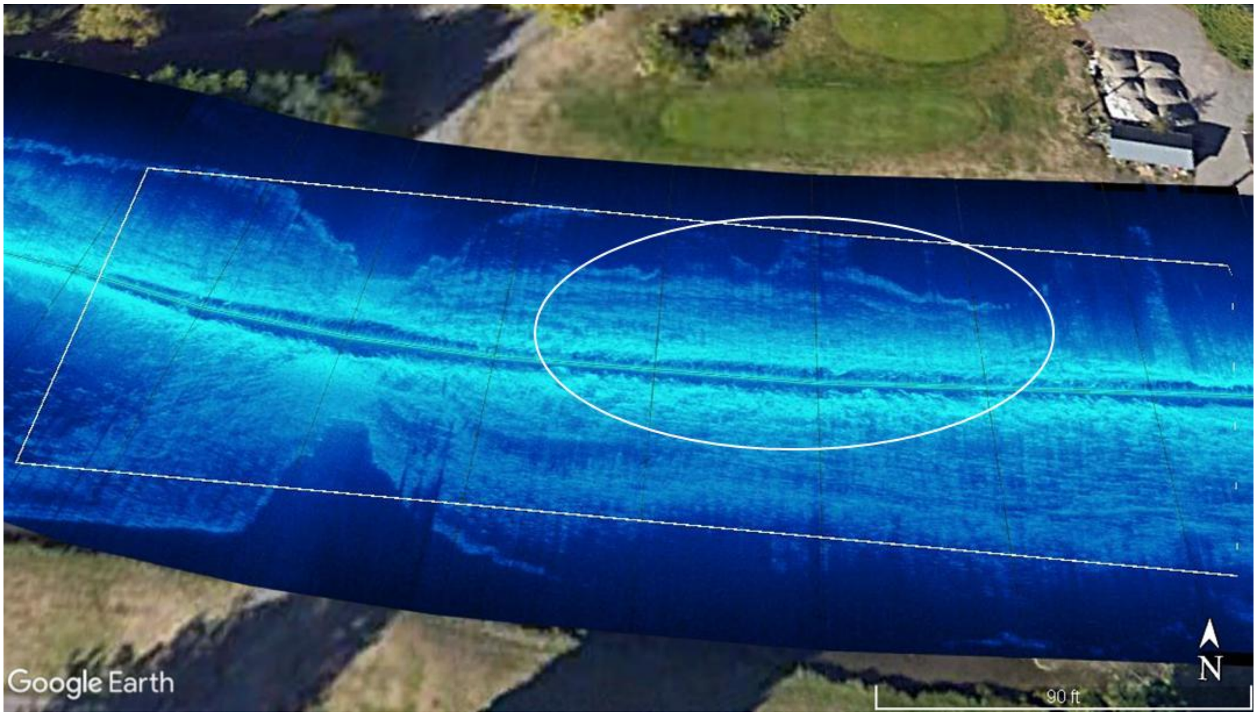


Figure 7. Reach 6, 143rd Avenue levee to Fairview Lake.



Reach 6: We ended our sonar path 0.35 miles west of Fairview Lake due to shallow depth. The substrate in Reach 6 was largely composed of mud, although dense vegetation prevented us from capturing clear images of the sediment. Image 1 shows a patch of mud visible through the vegetation. Images 2, 3, and 4 show vegetation throughout reach 6. Image 5 illustrates interference in the sonar image from vegetation surrounding the sonar transponder. Some naturally occurring wood was present in Reach 6 (Image 6), although less than in some of the other reaches.



The image above shows a dense concentration of Hydrilla. Notice within the oval highlighted area how the water column is inundated with vegetation. The sonar reflects this vegetation as a brighter, more intense blue, and the image reads as somewhat blurry. The image below is a photo of Hydrilla growth at the 143rd Avenue levee.

REACH 7

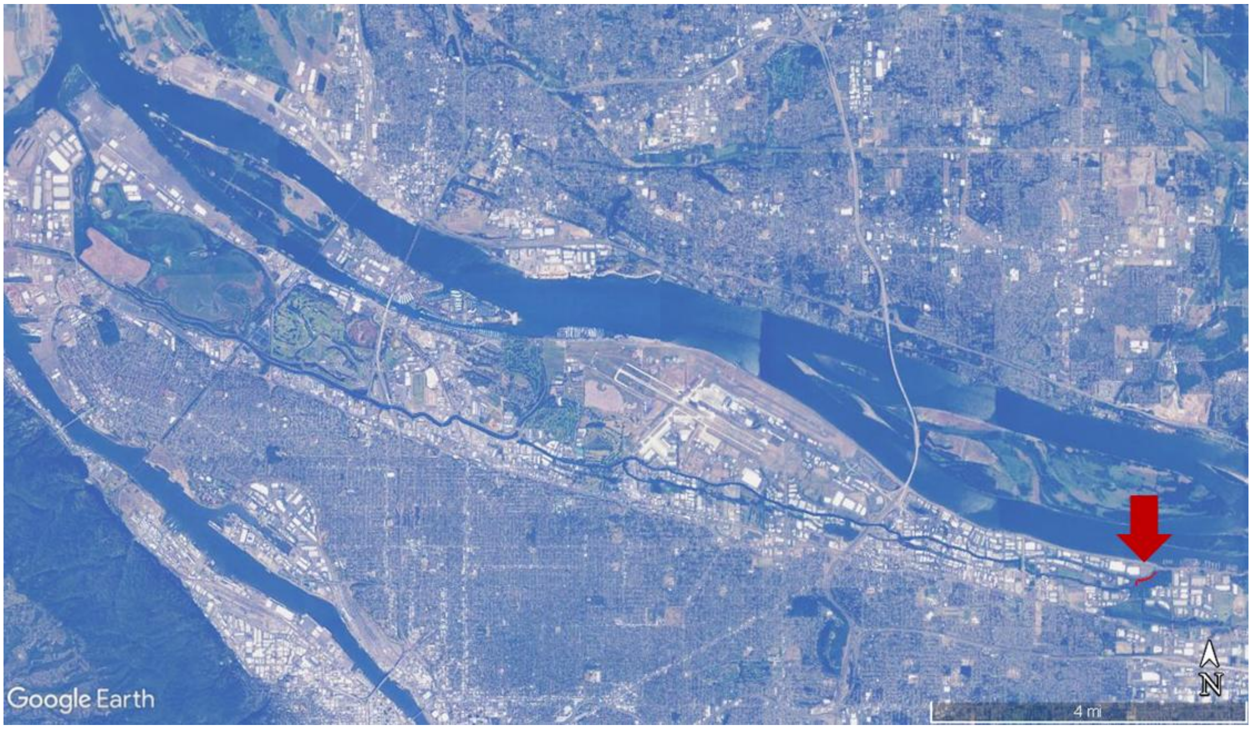
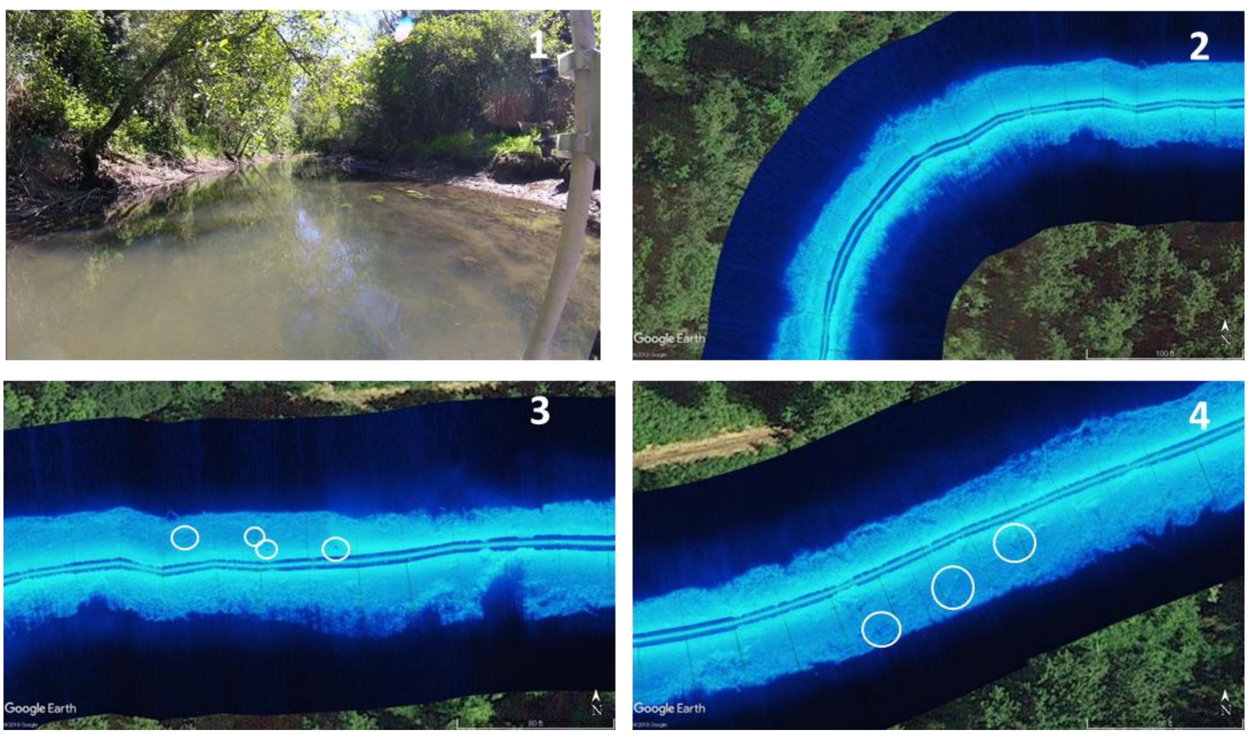
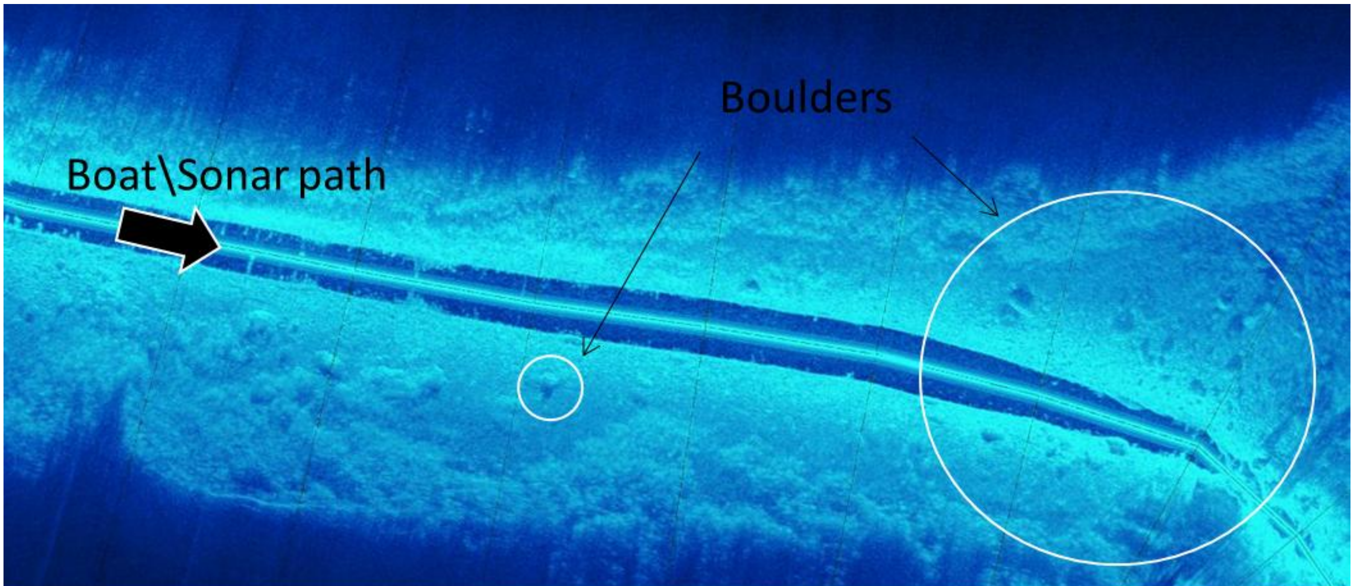


Figure 8. Reach 7, Big Four Corners Junction side channel.



Reach 7: Approximately 0.34 mi in length, the sediment in this section is predominately mud. Shallow depths were observed throughout along with aquatic vegetation. Image 1 is a typical

snapshot from this reach, showing shallow water and vegetation. Image 2 shows the mud substrate, with vegetation toward the edges of the channel. Image 3 shows some assorted small boulders and stumps on the bottom. Image 4 shows small pieces of wood.



The images above are from the Big Four Corners intersection. The sonar image shows mud substrate with a few boulders scattered throughout. The photograph shows the same location from above the water's surface.