

**U.S. Fish and Wildlife Service**

## **Tryon Creek Restoration Monitoring**

*2009 - 2012 Progress Report*

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*On the cover: Tryon Creek restoration below the Highway 43 culvert 2010, photo by Brook Silver.*

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# Tryon Creek Restoration Monitoring 2009 - 2012 Progress REPORT

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*Abstract* – Tryon Creek and its headwaters are located in southwest Portland. The lower portion of the stream is bisected by a culvert that runs under Oregon Highway 43 near the mouth. A collaborative project to improve passage conditions for anadromous fish is occurring in two phases. The initial phase retrofitted the existing culvert with a new baffle system to improve fish passage; the second will implement and provide a long-term solution by replacing the existing culvert. The U.S. Fish and Wildlife Service study will assess restoration response of multiple species historically present, or believed to be present, in Tryon Creek. Occupancy and distribution of larval Pacific and western brook lampreys in Tryon Creek was determined through electrofishing and spawning ground surveys. Occupancy, distribution, and abundance of salmonids were assessed through electrofishing, seining, and spawning ground surveys. In addition, salmonid movement through the Highway 43 culvert and at the confluence with the Willamette River was evaluated using passive integrated transponder arrays.

Larval lampreys were captured below the Highway 43 culvert. The probability that Tryon Creek is occupied with larval lamprey above the Highway 43 culvert is estimated to be  $< 0.02$ . Resident and juvenile salmonids were captured above and below the Highway 43 culvert. No evidence of anadromous salmonid or Pacific lamprey spawning was observed upstream of the Highway 43 culvert. Upstream passage of salmonids through the culvert has been documented by PIT tag detections at both ends of the Highway 43 culvert and capture of hatchery steelhead and juvenile salmon above the culvert. The majority of tagged coastal cutthroat have not been detected leaving the system, suggesting the resident form is dominant. The majority of coho and Chinook were detected leaving Tryon Creek after residing in Tryon Creek for 15 – 45 days after tagging, suggesting habitat in Tryon Creek below the Highway 43 culvert acts as a refuge for out-migrating juvenile salmonids from elsewhere in the Willamette basin.

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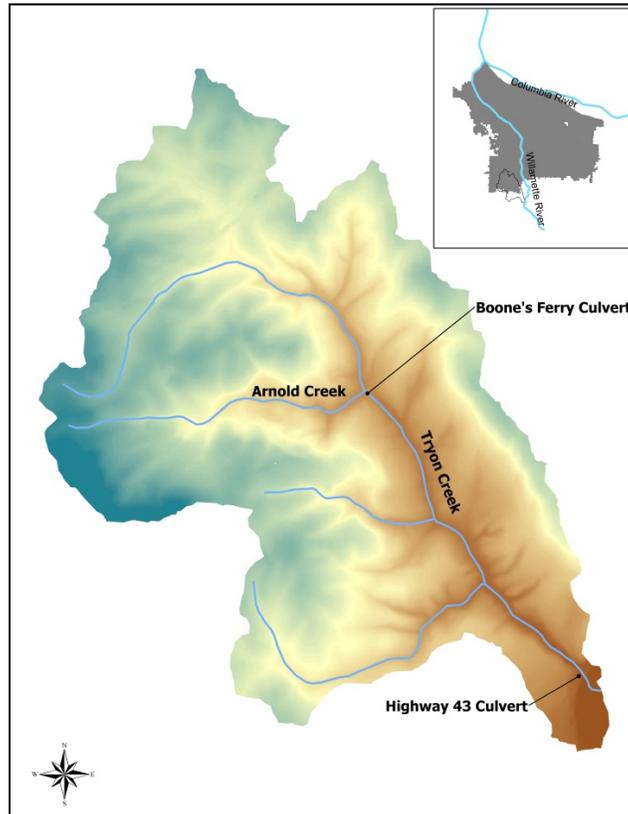
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## Introduction

Tryon Creek is located in southwest Portland and its headwaters are located within those neighborhoods (Figure 1). It flows approximately 5 km through this privately owned land before entering Tryon Creek State Natural Area, a 259 hectare area of public land, through which the stream flows another 5 km. The lower portion of Tryon Creek flows through public land owned by the City of Lake Oswego and the City of Portland. This portion of the stream is bisected by a culvert that runs under Oregon Highway 43 and a railroad near the mouth of Tryon Creek.



**Figure 1. Tryon Creek Watershed**

A collaborative project has been implemented by Oregon Department of Transportation (ODOT), Oregon Department of Fish and Wildlife (ODFW), Oregon State Parks (OSP), National Marine Fisheries Service (NMFS), Cities of Portland (COP) and Lake Oswego (COLO), Friends of Tryon Creek (FTC), Tryon Creek Watershed Council (TCWC), National Fish and Wildlife Foundation (NFWF) and the U.S. Fish and Wildlife Service (USFWS) to improve passage conditions for anadromous fish migrating into Tryon Creek. A replacement project for the Highway 43 culvert is proposed to occur in two phases. The initial phase (conducted in August 2008) retrofitted the existing culvert with a new baffle system to improve fish passage. The efforts also provided habitat restoration to the stream which included raising the level of the pool below the culvert to create a swim-in, rather than jump-in, situation thought to be more beneficial to lamprey and salmonid passage. The second phase, if implemented, will

provide and implement a long-term solution to replace the existing culvert. Solutions currently being considered include a larger culvert or bridge (Henderson Land Services 2007).

The USFWS assessment and monitoring program is focused on monitoring the success of the Highway 43 culvert replacement project relative to fish. This program is being conducted in three phases: 1) pre-assessment and monitoring prior to the initial phase of culvert improvement; 2) post-assessment and monitoring subsequent to the initial phase and pre-assessment and monitoring prior to the second phase of culvert replacement; 3) post-assessment and monitoring subsequent to the completed culvert replacement project.

The focus of the assessment and monitoring project was originally directed at Pacific and western brook lampreys in Tryon Creek. That focus has been expanded to include salmonids, specifically *O. mykiss*, and coastal cutthroat trout. The study will assess the restoration response of multiple species historically present, or believed to be present, in Tryon Creek. The objectives are broken into three species groups as follows:

- Lamprey
  1. Determine the distribution of larvae in Tryon Creek.
  2. Determine whether adult Pacific lampreys enter the culvert.
  3. Determine whether adult Pacific lampreys successfully pass through the culvert.
  4. Determine distribution of adult Pacific lamprey spawning.
  
- Salmon and Steelhead (anadromous *O. mykiss*)
  1. Determine whether juveniles and adults enter the culvert.
  2. Determine whether juveniles and adults pass through the culvert.
  3. Determine the upstream passage efficiency of juveniles and adults through the culvert.
  4. Determine if salmon and steelhead trout occupy Tryon Creek above the culvert.
  5. Describe distribution of salmon and steelhead above the culvert.
  
- Coastal cutthroat trout and resident *O. mykiss*
  1. Determine whether juvenile and adult trout species enter the culvert.
  2. Determine whether trout species successfully pass through the culvert at any life stage.
  3. Determine the upstream passage efficiency of resident trout species through the culvert.
  4. Describe distribution of trout species above the culvert.
  5. Estimate the relative population abundance of trout species above the culvert.

In July 2012, additional work between the City of Portland and U.S. Fish & Wildlife Service began to assess community, abundance, and temporal use of fish in the Tryon Creek confluence habitat between the Highway 43 culvert and the mouth of Tryon Creek with the following objectives:

1. Determine fish species community throughout the year.
2. Estimate abundance of fish species present each month of the year.

3. Document temporal use of this area by the fish species present during the spring/summer.

***Relationship to the Fisheries Program Strategic Plan***

Implementation of this project demonstrates application of the Pacific Region's 2009-2013 Fisheries Program Strategic Plan. The following National goals (NG) and Regional objectives (RO) have been addressed by this project:

- NG1 Open, interactive communication between the Fisheries Program and its partners.
  - RO1.1 Develop and maintain relationships with partners throughout the Pacific Region.
  - RO1.3 Improve data collection and management and internal and external reporting to reduce redundancy and improve access and usefulness for ourselves and our partners.
  
- NG2 America's streams, lakes, estuaries, and wetlands are functional ecosystems that support self-sustaining communities of fish and other aquatic resources.
  - RO2.1 Facilitate management of aquatic habitats on national and regional scales by working with Tribes, States, partners and other stakeholders.
  - RO2.2 Develop and expand the use of its expertise to help avoid, minimize or mitigate impacts of habitat alteration on aquatic species and monitor and evaluate completed projects.
  - RO2.4 Expand opportunities to connect people with nature, engage citizen scientists and volunteers, and temporarily employ youth in the aquatic habitat conservation and monitoring programs and activities we lead or support.
  
- NG3 Self-sustaining populations of native fish and other aquatic resources that maintain species diversity, provide recreational opportunities for the American public, and meet the needs of tribal communities.
  - RO3.1 Collaborate with Ecological Services (ES) Program, National Oceanographic and Atmospheric Administration Fisheries (NOAA Fisheries) and others, to recover fish and other aquatic resource populations protected under the ESA.
  - RO3.2 Maintain healthy, diverse, self-sustaining populations of fish and other aquatic resources
  - RO3.3 Support the research and fish culture needed to prevent listing or to recover native species listed or proposed for listing under ESA.
  
- NG9 Science developed and used by Service employees for aquatic resource restoration and management is state-of-the-art, scientifically sound and legally defensible, and technological advances in fisheries science developed by Service employees are available to partners.

RO9.2 Use state-of-the-art, scientifically sound, legally defensible scientific and technological tools in formulating and executing fishery-related plans and policies.

## Study Area

Tryon Creek (approximately 1,680 hectares) is one of the largest, relatively protected, urban watersheds in Oregon. A number of native fish species can be currently found in this stream including *Oncorhynchus mykiss* (resident and anadromous), coastal cutthroat trout (*O. clarki*) (CCT) (Tinus et al. 2003), as well as coho (*O. kisutch*) and Chinook salmon (*O. tshawytscha*) (CHN) (Hudson et al. 2009). Historically, it is thought that Pacific lamprey (*Entosphenus tridentatus*) and western brook lamprey (*Lampetra richardsoni*) as well as other salmon species also utilized this stream. However, the culvert under Highway 43 and the adjacent railroad is potentially inhibiting, if not preventing, passage of lampreys and salmonids.

The Highway 43 culvert was constructed in the late 1920s. It is approximately 122 m (401 ft.) long with a drop of nearly 6.7 m (22 ft.) from top to bottom, resulting in an average grade of 4.6% (Figure 2). There are a series of baffles that provide some structure within the culvert, holding water for fish attempting to migrate upstream through the culvert.

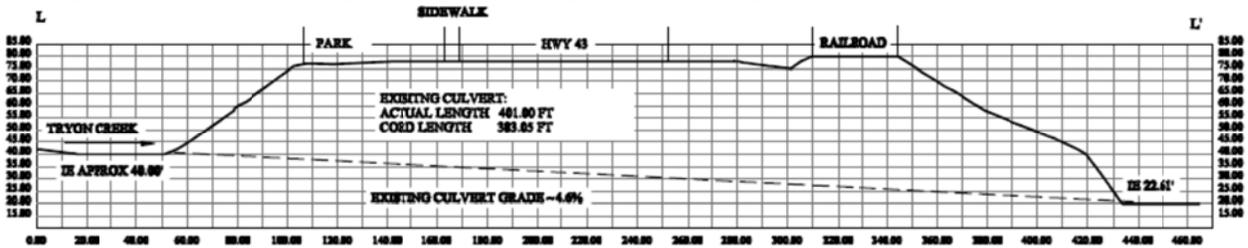
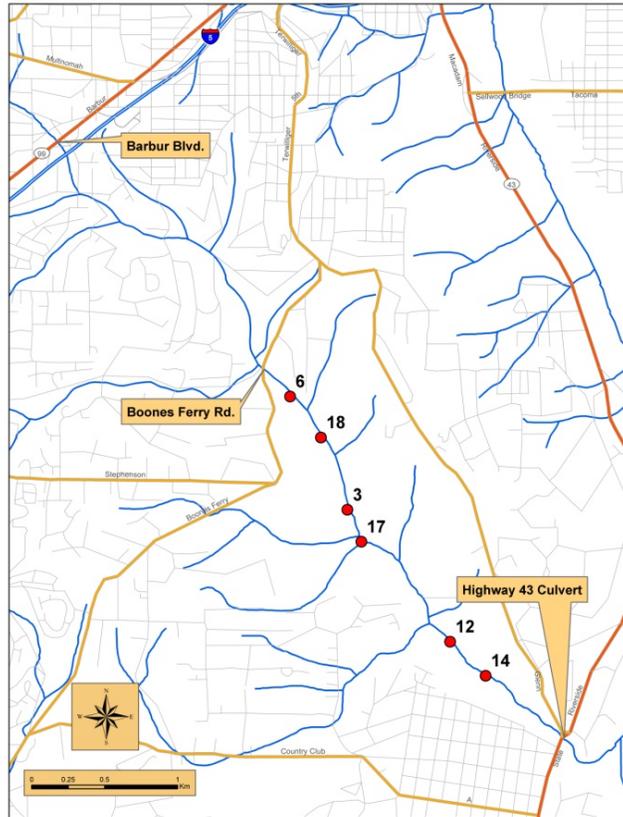


Figure 2. Longitudinal profile of Tryon Creek culvert (Henderson Land Services 2007).

## Methods

### *Lamprey Occupancy*

Occupancy of larval Pacific and western brook lampreys in Tryon Creek was determined beginning in 2010 through electrofishing surveys using an ABP-2 backpack electrofisher (ETS Electrofishing, Verona, WI). A generalized random tessellation stratified (GRTS) survey design was generated in 2010 and applied through 2012 to Tryon Creek (Stevens and Olsen 2004) resulting in six randomly-selected spatially-balanced 50 m sample reaches between the Highway 43 culvert and Boones Ferry Road (Figure 3). In addition, the entire reach from the mouth of Tryon Creek to the Highway 43 culvert was sampled. This design, along with information on the probability of detecting ammocoetes using a backpack electrofisher in wadeable streams (unpublished data), could be used to estimate the probability that lamprey were present in Tryon Creek. Based on information from other, similar tributaries in the area, we assumed that the site-specific probability of detecting lamprey by electrofishing in Tryon Creek, if they were there, was no less than 0.75 (Poirier et al. 2010).

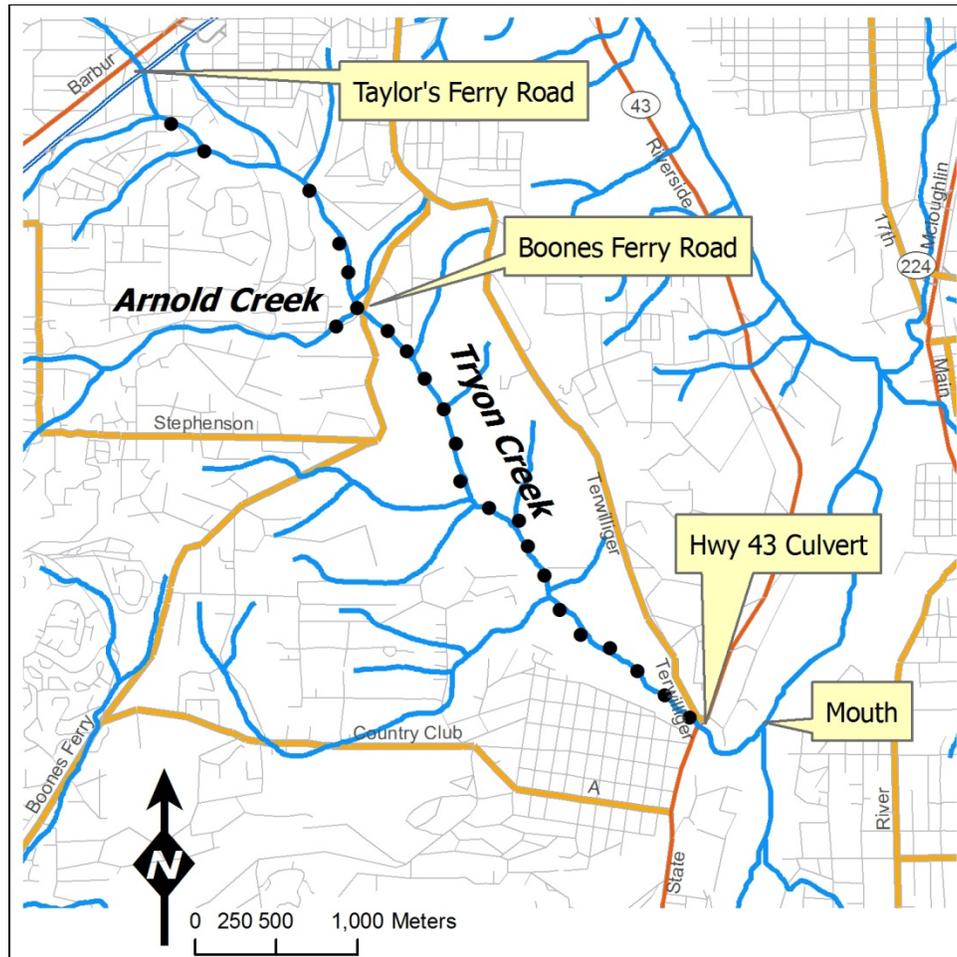


**Figure 3. The GRTS survey design applied to Tryon Creek resulting in six randomly-selected spatially-balanced 50 m sample reaches between the Highway 43 culvert and Boones Ferry Road.**

### *Salmon, Steelhead and Coastal Cutthroat Trout*

- a) *Abundance* - The population abundance of trout species in Tryon Creek above Highway 43 was estimated using a multiple pass mark-recapture or single-pass approach in fall 2009 and 2011. The estimate included the lower portion of Arnold Creek between the Boones Ferry Road and the culvert at SW Arnold St (approximately 200 m). The sample method consisted of backpack electrofishing using a Smith-Root model LR-24 shocker. Sample reaches (Figure 4) measured approximately 200 m (as identified by ArcGIS and GPS technology), combining for a total of 5.4 km of stream (Hudson et al. 2009). Two netters worked with one electrofisher; the fishing effort was similar to passes conducted in 2009 (Silver et al. 2010). The LR-24 shocker used pulsed direct current set at a frequency of 24 - 25 Hz, 12-14% duty cycle, and voltage between 300 and 400 V. All settings were subject to modification depending on conditions (i.e. water depth, conductivity, flow). Electrofishing was conducted identically for marking, recapture or single-pass efforts.

In summer 2010, two-pass abundance estimates for salmonids were estimated between the confluence and the Highway 43 culvert. Electrofishing was conducted as described above from the mouth up to the pool just below the culvert. Immediately below the Highway 43 culvert, a deep, non-wadeable pool exists where electrofishing is not an efficient sampling method. Therefore, an unbagged 15.2 m long 1.8 m deep, 0.6 cm mesh seine net with float and lead lines was utilized for sampling the Highway 43 culvert pool.



**Figure 4. The Tryon Creek study area. Sixteen reaches between the Highway 43 culvert and the Boones Ferry Road crossing, and five reaches in Upper Tryon Creek above Boones Ferry Road to Taylors Ferry Road. One reach in Arnold Creek above Boones Ferry Road.**

At the completion of each sampling reach, all captured fish were anesthetized using 25 ppm clove oil, identified, measured (fork length), weighed, and scanned for passive integrated transponder (PIT) tags. Coastal cutthroat trout and *O. mykiss* hybridization (HYB) was determined in the field by evidence of diagnostic characteristics for both species. Phenotypic characteristics such as a break in the outer line along the adipose fin, a maxilla that extends past the orbital socket, the presence of basibranchial teeth, and the orange coloration on the lower maxilla (all cutthroat appearances) were utilized to distinguish hybridized fish (Hawkins 1997). For untagged salmonids greater than 100 mm, a PIT tag (23 mm long, 3.84

mm diameter, 0.6 g, full duplex) was surgically implanted on the ventral side, posterior to the pectoral fins (Roussel et al. 2000). For untagged salmon 70 – 100 mm, a PIT tag (12 mm long, 2 mm diameter, 0.1 g, full duplex) was surgically implanted on the ventral side, posterior to the pectoral fins. After full recovery within an aerated bucket, all fish were released at the top of the reach from which they were captured.

Multiple pass mark-recapture data was analyzed using CAPTURE (Otis et al. 1978; White et al. 1982; Rexstad and Burnham 1991) within MARK (White and Burnham 1999) or the Lincoln-Petersen method (Seber 1973). CAPTURE determined confidence intervals around the estimate, the coefficient of variation, and the probability of capture. Single-pass data was analyzed using the population estimate for single catches method (Seber and Le Cren 1967):

$$\tilde{N} = C/\tilde{p},$$

where  $\tilde{N}$  is the estimated abundance,  $C$  is the number of captured individuals from the single-pass, and  $\tilde{p}$  is the estimated capture probability. Capture probability was estimated to be 0.38, the same as capture probability generated from the 2008 mark-recapture estimate in Tryon Creek (Hudson et al. 2009). Confidence intervals (95%) around the single-pass estimate were generated using the methodology of Seber and Le Cren (1967).

- b) *Distribution* – Distribution of all salmonids was described among sites throughout the Tryon Creek watershed from an occupancy sample design employed in fall 2011. The approach is designed to quantify occupancy of the watershed by a given species. We used presence of salmonids in identified reaches to describe both the distribution of species and size classes within those species through the watershed. The determination of sample sites was different than those used for estimating abundance. It was done using a random, spatially-balanced GRTS design developed by the Environmental Protection Agency Environmental Monitoring and Assessment Program. Sample sites were identified on a 1:100 k stream layer using Program R (Gentleman and Ihaka, 1996) at a density of 1 site every 500 m. Each sample site represented a 50 m reach. Sampling was conducted using a Smith-Root model LR24 backpack electrofisher and was sampled from downstream to upstream boundary, no blocknets were used. All fish encountered were captured and measured for size class determination. Fish were measured and counted within five size classes (<120, 120-149, 150-179, 180-209 and >210). Sites located on Tryon Creek were sampled in conjunction with the first pass of the abundance estimate. The remaining sites (Nettle creek, Arnold Creek, etc.) were sampled during separate effort. All fish captured were released alive within the sampled reach.

### ***Fish Passage***

- a) *Spawning ground surveys* – Spawning ground surveys were conducted between January 2009 and March 2011 every other week in search of active spawning, redds, and/or carcasses of lamprey or salmonids. Surveys were conducted from the mouth of Tryon Creek to Boones Ferry Road. Live Pacific lamprey, salmon or other anadromous fish (for example, O. mykiss), their redds and/or carcasses above the Highway 43 culvert would indicate upstream passage.

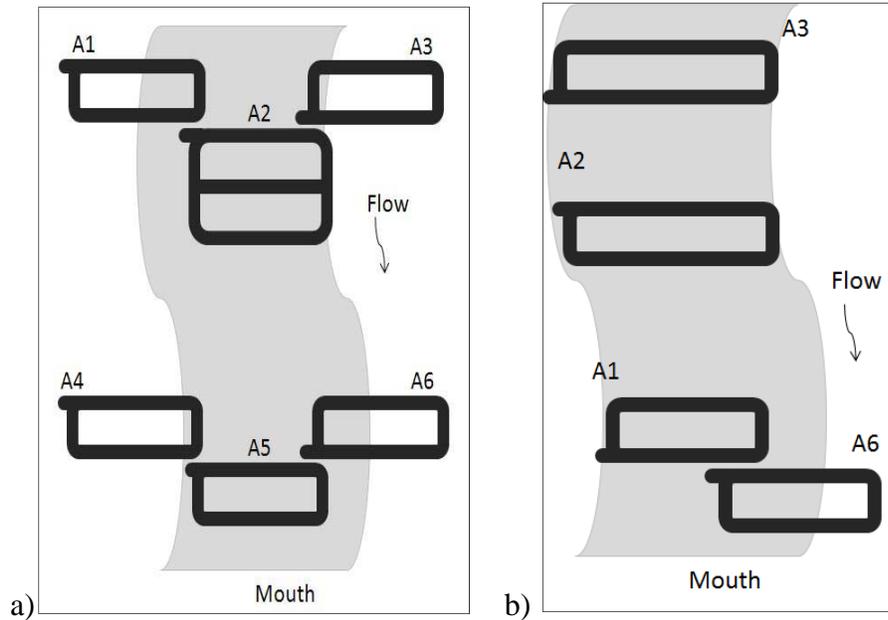
- b) *Upstream Passage*– Upstream passage through the Highway 43 culvert was assessed utilizing a combination of known tagging locations and movement determined by PIT tag antenna detections. PIT tag antennas were maintained at the downstream and upstream openings of the Highway 43 culvert. A PIT tag antenna was maintained throughout 2009, 2010 and 2011 at the upstream opening of the Highway 43 culvert (TCU). This antenna was destroyed by high flows and woody debris in January 2012, replaced in September 2012, and destroyed again in December 2012 by high flows. Two antennas located at the downstream opening of the culvert (TCL) installed in September 2009 were destroyed by high flows in November 2010 followed by vandalism at the site in April 2011. This site was replaced in October 2012 and destroyed again in December 2012 by high flows. Efficiency testing of antennas used 20 corks, six tests were completed on two occasions in 2009. The average antenna efficiency was determined to be TCU = 96% and TCL = 83%. PIT tagged fish moving over or through these antennas were detected and identified. The PIT tag code and time of detection was logged on a Biomark Multiplexing Transceiver (FS 1001M) from which data was downloaded on a monthly basis. Mean daily flow (cfs) for Tryon Creek (USGS gage # 14211315) was documented for days fish were known to successfully move upstream through the culvert. A range of mean daily flows was identified in an attempt to identify a percentage of days when flow conditions could allow successful upstream passage.
- c) *Upstream Passage Efficiency* – Upstream passage efficiency was determined using the TCL and TCU PIT tag antennas on either end of the Highway 43 culvert. Rate of entry was determined by number of tagged fish detected by TCL entering the culvert. Rate of passage was determined by number of tagged fish detected initially by TCL and subsequently by TCU at the top of the culvert.

### ***Confluence Monitoring***

To assess community and temporal use of fish in the confluence of Tryon Creek and the Willamette River between July and December 2012, electrofishing occurred in a single pass from the mouth of Tryon Creek to the Highway 43 culvert pool. The Highway 43 culvert pool was then sampled with a seine in two passes. Backpack electrofishing was conducted using a Smith-Root model LR-24 shocker in a manner to reduce potential harm to the sampled population. Specifically, all areas considered holding habitat for salmonid species (plunge pools, overhanging banks, eddies, large woody debris, and pocket pools within riffles) were sampled in a “stalk and shock” approach. The LR-24 shocker used pulsed direct current set at a frequency of 24 - 26 Hz, 12 - 18% duty cycle, and voltage between 350 and 375 V. All settings were subject to modification depending on conditions (i.e. water depth, conductivity, flow). Immediately below the Highway 43 culvert, a deep, non-wadeable pool exists where electrofishing is not an efficient sampling method. Therefore, an unbagged 15.2 m long 1.8 m deep, 0.6 cm mesh seine net with float and lead lines was utilized for sampling the Highway 43 culvert pool. Fish were identified and tagged as previously described.

Six PIT tag antennas were installed at the mouth of Tryon Creek in November 2011 (TCM) and destroyed by high flows in January 2012. The array was reconfigured by reinstalling A1 and A6 in March 2012 and installing A2 and A3 in September 2012. In December 2012, A3 was

removed for the winter season to prevent loss. The present array at the mouth is comprised of antennas spanning the creek in two locations to assess directionality of fish passage (Figure 5). PIT tagged fish moving over or through these antennas were detected and identified. The PIT tag code and time of detection was logged on a Biomark Multiplexing Transceiver (FS 1001M) from which data was downloaded on a monthly basis.



**Figure 5. A diagram of the TCM antenna array a) Winter 2011 and b) 2012 configuration.**

## Results

### *Lamprey Occupancy*

- a) *2009* – Zero larval lampreys were captured below or above the Highway 43 culvert in 2009. Given an estimated site-specific detection probability of 0.75, with no lamprey being detected in six reaches, the probability that Tryon Creek is occupied with larval lamprey is estimated to be  $< 0.02$ . No adult lamprey (live or dead) were captured or detected above or below the Highway 43 culvert, therefore, passage did not appear to occur and efficiency could not be estimated.
- b) *2010* – Zero larval lampreys were captured below or above the Highway 43 culvert in 2010. Given an estimated site-specific detection probability of 0.75, with no lamprey being detected in six reaches, the probability that Tryon Creek is occupied with larval lamprey is estimated to be  $< 0.02$ . No adult lamprey (live or dead) were captured or detected above or below the Highway 43 culvert, therefore, passage did not appear to occur and efficiency could not be estimated.

- c) 2011 – Lamprey sampling was conducted in the six GRTS reaches above the Highway 43 culvert on 8/2/2011 and the entire lower reach from the mouth of Tryon Creek to the culvert 8/3/2011. Two larval Pacific lampreys (93 and 112 mm) were captured below the Highway 43 culvert and zero were captured above the culvert. Given an estimated site-specific detection probability of 0.75, with no lamprey being detected in six reaches, the probability that Tryon Creek is occupied with larval lamprey above the Highway 43 culvert is estimated to be < 0.02. No adult lamprey (live or dead) were captured or detected above or below the Highway 43 culvert, therefore, passage did not appear to occur and efficiency could not be estimated.
- d) 2012 – Lamprey sampling was conducted in the six randomized reaches above the Highway 43 culvert and the entire lower reach from the mouth of Tryon Creek to the culvert on 6/4/2012. Zero larval lampreys were captured below or above the Highway 43 culvert in 2012. Given an estimated site-specific detection probability of 0.75, with no lamprey being detected in six reaches, the probability that Tryon Creek is occupied with larval lamprey is estimated to be < 0.02. No adult lamprey (live or dead) were captured or detected above or below the Highway 43 culvert, therefore, passage did not appear to occur and efficiency could not be estimated.

***Salmon, Steelhead and Coastal Cutthroat Trout***

a) *Abundance*

- 2009

In the spring of 2009, the abundance estimate survey above Highway 43 was cancelled due to the observation of resident redds (see “fish passage results”). The fall single-pass survey above Highway 43 was conducted 9/16/2009 - 9/18/2009 and resulted in 214 trout (CCT, HYB, *O. mykiss* combined) >100 mm (Table 1). Below the Highway 43 culvert, twenty trout >100 mm, two coho (82 and 109 mm), and fifteen Chinook salmon <100 mm were captured using electrofishing only (Table 1).

**Table 1. Total number of salmonids captured in the fall 2009 single pass abundance estimate**

9/16/09-9/18/09	Below Culvert				Above Culvert				Total Captures
	Tagged	Recaptures	Not Tagged	Sub total	Tagged	Recaptures	Not Tagged	Sub total	
CCT (>100 mm)	6	0	0	6	99	14	1	114	120
HYB (>100 mm)	5	1	0	6	80	7	0	87	93
<i>O. mykiss</i> (>100 mm)	5	3	0	8	13	0	0	13	21
Coho (juvenile)	2	0	0	2	0	0	0	0	2
CHN (juvenile)	14	0	1	15	0	0	0	0	15
<b>Total</b>	32	4	1	37	192	21	1	214	251

A probability of capture of 0.38 for all trout species above the culvert was determined in 2008 (Cook et al. 2009). Given this, the estimated abundance of trout >100 mm, between the Highway 43 culvert and S.W. 18th Place, was calculated as  $563 \pm 40.58$  individuals in 2009.

Tryon Creek was sampled using only electrofishing from its confluence with the Willamette River to the pool below the Highway 43 culvert on four additional occasions to increase the number of PIT tagged fish below the Highway 43 culvert (Table 2).

**Table 2. Total number of salmonids captured below the Highway 43 culvert in 2009**

Date	CCT >100 mm	HYB >100 mm	<i>O. mykiss</i> >100 mm	Coho	CHN	Total Captured	Total Tagged	Total Recaps
3/4/2009	0	0	5	0	0	5	4	0
4/8/2009	1	1	8	3	0	13	0	1
4/24/2009	3	0	11*	0	0	14	14	0
6/8/2009	3	4	9	0	0	16	16	1

\*Hatchery clipped fish (6 *O. mykiss*)

- 2010

A two-pass abundance estimate occurred below the Highway 43 culvert 7/1/2010. Sixty-six coho and 32 trout were captured during electrofishing and seine sampling (Table 3). The Lincoln-Petersen probability of capture was 0.61 and 0.74 for trout and coho salmon, respectively. The abundance estimate of trout was  $32.83 \pm 1.81$  and  $68.73 \pm 2.10$  for coho. Other species captured below the Highway 43 culvert included one brown bullhead (*Ameiurus nebulosus*) (BBH), one mountain whitefish (*Prosopium williamsoni*) (WHF), and 112 sculpin (*Cottus spp.*) (SCP).

**Table 3. Total number of salmonids captured in the summer 2010 two-pass abundance estimate below the Highway 43 culvert.**

7/1/2010	Tagged	Recaptures	Not Tagged	Total
CCT (>100 mm)	7	17	2	26
HYB (>100 mm)	0	0	0	0
<i>O. mykiss</i> *(>100 mm)	3	0	0	3
TF** (<100mm)	2	0	1	3
Coho (juvenile)	15	43	8	66
CHN (juvenile)	0	0	0	0
<b>Total</b>	<b>27</b>	<b>60</b>	<b>11</b>	<b>0</b>

\*1 Hatchery *O. mykiss*

\*\*1 TF mortality-not marked

- 2011

The first electrofishing pass above the Highway 43 culvert (9/12 - 9/14/2011) resulted in 214 trout >100 mm (Table 4). The second electrofishing pass (10/6 – 10/7/2011) resulted in 187 trout >100 mm (Table 4). Following the completion of the second pass, a probability of capture of 0.22 was calculated for all trout species. The estimated

abundance of trout > 100 mm between the Highway 43 culvert and S.W. 18th Place was  $891 \pm 104.2$  individuals for 2011.

**Table 4. Total number of salmonids captured in the fall 2011 two-pass abundance estimate above the Highway 43 culvert.**

Pass Dates	CCT >100mm	HYB >100mm	<i>O. mykiss</i> >100mm	Total Captured	Tagged	Recaptured	Total Marked
9/12-9/14	189	23	2	214	193	14*	207
10/6-10/7	134	51	2	187	0	44**	0

\* Tagged in previous years

\*\* Fish tagged in previous years were not counted as recaptured unless they were captured during Pass 1.

One coho (113 mm) was captured in the first pass, three coho (100, 110, 120 mm) were captured in the second pass; no Chinook were found in either pass. Salmon abundance was not estimated.

A single-pass survey using electrofishing only below the Highway 43 culvert (9/16/2011) resulted in thirteen trout >100 mm, two coho (109 and 117 mm), and eight Chinook salmon <100 mm. Other species captured below the culvert included one speckled dace (*Rhinichthys osculus*) (SPD). No nonnative fish species were captured above the Highway 43 culvert.

b) *Distribution*

- 2011

Distribution sampling occurred in conjunction with Pass 1 of the abundance estimate in the mainstem of Tryon Creek (9/12 - 9/14/2011) and a separate pass in Nettle Creek, a tributary of Tryon Creek (9/29/2011). A total of 79 trout were captured in sixteen reaches; all size classes were present. The only reaches (2) trout were not present were in the headwaters of Nettle Creek (5, 9).

***Fish Passage***

a) *Spawning Ground Surveys*

- 2009

Twenty three surveys were conducted between January and November 2009. No spawning evidence (live spawners, carcasses or redds) of salmon, *O. mykiss* or Pacific lamprey was observed upstream of the Highway 43 culvert. Below the Highway 43 culvert, one adipose marked female CHN salmon carcass was observed at the mouth of Tryon Creek (7/10/2009). On two occasions, an untagged adult wild coho salmon was observed at the mouth of Tryon Creek (9/24/2009 and 10/9/2009).

Resident fish redds were observed from 3/26/2009 to 6/8/2009 between the Iron Mountain Bridge and the Red Fox Bridge of Tryon Creek State Park. No redds have been observed below the Highway 43 culvert or above High Bridge. The peak redd count, totaling 38, occurred April 8, 2009. No spawning surveys were conducted above SW Boone's Ferry Road.

- 2010

Twenty five surveys were conducted between January and December 2010. No spawning evidence (live spawners, carcasses or redds) of salmon, *O. mykiss* or Pacific lamprey was observed upstream of the Highway 43 culvert. On 6/29/2010, two, wild steelhead, one a carcass, were observed below the Highway 43 culvert. Resident fish redds were not observed. No spawning surveys were conducted above SW Boone's Ferry Road.

- 2011

Three spawning ground surveys were conducted between January and March 2011. No spawning evidence (live spawners, carcasses or redds) of salmon, *O. mykiss* or Pacific Lamprey was observed upstream of the Highway 43 culvert. Resident fish redds were not observed. No spawning surveys were conducted above SW Boone's Ferry Road.

b) *Upstream Passage*

- 2009

During the time of operation in 2009, detections for both the Tryon Creek upper (TCU) and the Tryon Creek lower (TCL) antennas resulted in a total of 7,744 detections of 80 unique fish, 36 fish were detected at both antennas. TCU operated all year excluding two weeks in January (1/1/2009-1/16/2009) when the existing antenna was destroyed during a storm event and a new one was installed. In addition, data downloaded from TCU 10/21/2009 - 12/3/2009 was irretrievable due to a corrupted file.

TCU recorded 3,374 detections from 40 unique fish. Of these unique detections, 6 individuals were tagged and released downstream of the Highway 43 culvert, the remaining 32 were tagged and released from upstream locations (2007 - 2009).

TCL was installed 2/20/2009 and operated until 5/11/2009 when it broke loose during a high velocity water event (300 cfs); it was reinstalled 5/22/2009. USFWS removed TCL 8/10/2009 for ODOT culvert maintenance and reinstalled it 9/2/2009. During the time of operation in 2009, TCL recorded a total of 4,370 detections from 76 unique fish. Of these unique detections, 45 individuals were tagged and released downstream of the Highway 43 culvert and 31 were tagged and released from upstream locations. Two juvenile spring Chinook raised at McKenzie Hatchery (ODFW) were tagged and released (133 and 145 mm at release in November 2009) in the Willamette River at river km 55 (about 8 km above Willamette Falls) were detected by TCL antenna in November 2009.

Predominantly, salmonids tagged upstream moved downstream during the spring months. The peak of antenna detections was in April when 19 unique tags were detected.

- 2010

During the time of operation in 2010, detections for both the Tryon Creek upper (TCU) and the Tryon Creek lower (TCL) antennas resulted in 6,789 detections of 91 unique tags. Of these detections, 10 fish (8 CCT, 1 HYB, and 1 *O. mykiss*) were detected at both antennas, five (3 CCT, 2 *O. mykiss*) were detected only at TCL, and 68 (34 CCT, 1 CHN Hatchery, 17 HYB, and 16 *O. mykiss*) were detected only at TCU. The remaining eight tags were seeded upstream of the culvert for a PIT tag retention study and were only detected at TCU. TCU recorded 6,578 detections from 78 unique fish. Of these unique detections, 16 (11 CCT, 3 HYB, and 2 *O. mykiss*) were originally tagged and released downstream of the Highway 43 culvert, the remaining 62 (31 CCT, 1 CHN Hatchery, 15 HYB, and 15 *O. mykiss*) were tagged and released from upstream locations (2007-2010). TCL recorded 195 detections from 15 unique fish. Of these unique detections, 11 (7 CCT, 1 HYB, and 3 *O. mykiss*) were originally tagged and released downstream of the Highway 43 culvert, the remaining four CCT were released from upstream locations (2008-2010). TCL was offline 1/18/2010 to 2/11/2010 when the circuit breaker tripped caused by water building up in storage box. In March 2010, two flat panel antennas were installed to replace the existing single antenna. The new antennas broke loose during a high velocity water event in August 2010; the last tag detection was recorded 8/21/2010. Predominantly, salmonids tagged upstream moved downstream during the spring months. The peak of antenna detections was in April when 44 unique tags were detected.
- 2011

During the time of operation in 2011, detections for the TCU antenna resulted in 55 detections of 21 unique tags. Of these detections, five CCT were originally tagged and released downstream of the Highway 43 culvert (2008-2010), 14 fish (7 CCT, 6 HYB, and 1 *O. mykiss*) were tagged and released from upstream locations (2007-2011), the remaining two tags were seeded upstream of the culvert for a PIT tag retention study in 2010. The TCL antennas broke loose during a high velocity water event in 2010 and were not operational in 2011. However, TCU still detected emigrating fish during this time. *O. mykiss* emigrated from Tryon Creek before reaching 130 mm. Predominantly, salmonids tagged upstream moved downstream during the spring months. The peak of antenna detections was in July when seven unique tags were detected.
- 2012

During the time of operation in 2012, TCU recorded 95 detections from 13 unique tags. Of these unique detections, 7 fish (4 CCT, 1 HYB, 1 coho, and 1 CHN) were originally tagged and released downstream of the Highway 43 culvert (2010-2012), the remaining 6 (CCT) were tagged and released from upstream locations (2007-2011). During a high flow event, the TCU antenna was destroyed 1/18/2012. Two tags from 2007 and one from 2011 were detected during this event. TCU was replaced 9/24/2012 and destroyed again during another high flow event 11/19/2012 when discharge reached 1,110 CFS (USGS 2012). TCL was offline in 2012. Two antennas were installed 10/8/2012 and destroyed before they were operational, during the same high flow event that destroyed TCU. Predominantly, salmonids tagged upstream moved downstream during the spring months. The peak of antenna detections was in January when six unique tags were detected.

During 2009-2012, 44 fish were detected moving upstream through the Highway 43 culvert. Fish passed upstream through the culvert when mean daily flow was greater than 0.64 CFS and less than 34 CFS. This range of mean daily flow was present for 92% of days between 5/14/2008 and 11/23/2012. Salmonid species (and number) detected were CCT (48), HYB (11), CHN (8), Coho (6), and *O. mykiss* (4). Fork length ranged from 102-223 mm. All but three fish were detected within 9 months of being tagged. The three exceptions were CCT that were detected in November 2009 (13 months after tagging at 137 mm), January 2010 (20 months after tagging at 218 mm), and March 2010 (20 months after tagging at 145 mm). All three of these fish were tagged below Highway 43 and not detected subsequently until these times. Upstream passage occurred in every month except August, which also exhibited the lowest average mean daily flow for any month during this period of time (Table 5).

**Table 5. Average mean daily flow (CFS) across years for each month between 5/14/2008 and 11/23/2012.**

Month	CFS	CFS	Month
Jan	22.0	1.7	Jul
Feb	11.0	1.1	Aug
Mar	20.1	1.4	Sep
Apr	11.7	3.4	Oct
May	7.0	12.2	Nov
Jun	6.1	16.0	Dec

c) *Upstream Passage Efficiency*

- 2009

Upstream passage of CCT, HYB, *O. mykiss* and coho has been proven by the detections from both TCL and TCU. Sixty three individuals were tagged and released below the culvert. The rate of entry at TCL was 70% (44/63) (significantly < 100% entered, Fisher's Exact,  $p < 0.001$ ). The passage efficiency rate of those fish that entered the culvert passing upstream was 14% (6/44) (significantly < 100% passed, fisher's exact,  $p < 0.0001$ ) (Table 6). It should be noted that due to corrupted data for TCU, not all fish known to enter the culvert were considered in this analysis because it is not known if those individuals were successful or not in upstream passage between 10/20/2009 - 12/3/2009.

**Table 6. 2009 fish passage efficiency rates for fish tagged below culvert moving upstream (TCU/TCL).**

	Passage Efficiency				
	Tagged Below Culvert	TCL Detection - Entry	TCU Detection - Passage	Rate of entry	Rate of passage upstream
<b>CCT</b>	11 (1)	9 (1)	2	0.82	0.22
<b>CHN</b>	13 (1)	6 (1)	0	0.46	0.00
<b>Coho</b>	1 (1)	1 (1)	0	1.00	0.00
<b>HYB</b>	9 (1)	8 (1)	3	0.89	0.38
<i>O. mykiss</i>	29	20	1	0.68	0.05
<b>Mean</b>				0.77	0.13

Only fish detected prior to 10/20/2009 were considered in this analysis. Numbers in parentheses represent fish detected after 10/20/2009.

- 2010

Upstream passage of CCT, HYB, *O. mykiss* and coho has been confirmed by the detections from both TCL and TCU. In 2010, 30 fish were tagged and released below the culvert. Six individuals were detected at both TCL and TCU, three additional fish were detected only at TCL, and three more were only detected at TCU. The rate of CCT entry at TCL was 44% (12/27) (significantly < 100% entered, Fisher's Exact, p<0.0001) and 0% for *O. mykiss*. The passage efficiency rate of those fish that entered the culvert passing upstream was 75% (9/12) (significantly < 100% passed, Fisher's Exact, p<0.001) (Table 7). It should be noted that due to TCL not operating as of 8/21/2010, not all fish known to enter the culvert were considered in this analysis because it is not known if those successfully passed upstream between 8/21/2010 to present. In addition, no nonnative fish species have been captured to date above the Highway 43 culvert.

**Table 7. 2010 fish passage efficiency rates for fish tagged below culvert moving upstream (TCU/TCL).**

	Tagged Below Culvert	TCL Detection - Entry	TCU Detection - Passage	Rate of entry	Rate of passage upstream
<b>CCT</b>	27	12*	9	0.44	0.75
<b>CHN</b>	0	0	0	0	0
<b>Coho</b>	0	0	0	0	0
<b>HYB</b>	0	0	0	0	0
<i>O. mykiss</i>	3	0	0	0	0

\*Three fish passed through culvert not detected by TCL

- 2011 - 2012

Upstream passage efficiency could not be determined in 2011-2012.

### ***Confluence Monitoring***

Sampling below the Highway 43 culvert was conducted on a monthly basis beginning 7/3/2012 (Tables 8 and 9). Species captured below the Highway 43 culvert included CCT, HYB, *O. mykiss*, Coho, CHN, trout fry (*O. sp.* < 100 mm) (TF), BBH, largemouth bass (*Micropterus salmoides*) (LMB), longnose dace (*Rhinichthys cataractae*) (LND), SCP, SKB, smallmouth bass (*Micropterus dolomieu*) (SMB), sucker (*Catostomus sp.*) (SUK), and WHF.

**Table 8. Summary of salmonids captured below Highway 43 each month.**

<b>Month</b>	<b>CCT</b>	<b>STH</b>	<b>Hyb</b>	<b>TF</b>	<b>CHN</b>	<b>Coho</b>	<b>WF</b>
<b>Jul</b>	<b>6</b>	<b>2</b>	<b>3</b>	<b>0</b>	<b>1</b>	<b>10</b>	<b>0</b>
<b>Aug</b>	<b>7</b>	<b>4</b>	<b>3</b>	<b>1</b>	<b>24</b>	<b>22</b>	<b>4</b>
<b>Sep</b>	<b>9</b>	<b>2</b>	<b>0</b>	<b>2</b>	<b>13</b>	<b>20</b>	<b>4</b>
<b>Oct</b>	<b>7</b>	<b>0</b>	<b>4</b>	<b>0</b>	<b>17</b>	<b>18</b>	<b>2</b>
<b>Nov</b>	<b>1</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>15</b>	<b>46</b>	<b>0</b>
<b>Dec</b>	<b>2</b>	<b>6</b>	<b>2</b>	<b>4</b>	<b>14</b>	<b>40</b>	<b>0</b>

The Tryon Creek mouth (TCM) antennas were installed in November 2011 and had three detections of one coho tagged above the Highway 43 culvert in November 2011.

During 2012, TCM recorded 895 detections from 61 unique fish. Of these unique detections, 49 (1 CCT, 13 CHN, 1 CHN-Hatchery origin, 30 coho, 2 HYB, 1 *O. mykiss*, and 1 WHF) were originally tagged and released downstream of the Highway 43 culvert (2012), eight (CCT) were released from upstream locations (2007-2011), the remaining 4 (CHN) were released upstream in the Willamette River Basin by Willamette Hatchery in 2012. Juvenile anadromous salmonids (14 CHN, 35 coho) captured below the Highway 43 culvert were detected emigrating from Tryon Creek 15 – 45 days after tagging. Resident salmonids (2 CCT, 2 HYB, and 1 STH) captured below the Highway 43 culvert were detected emigrating from Tryon Creek 22 - 128 days after tagging (Table 10).

**Table 9. Species captured below the Highway 43 culvert in 2012.**

<b>Sample Date</b>	<b>Sample Method</b>	<b>BBH</b>	<b>CCT</b>	<b>CCT-Recap</b>	<b>CHN</b>	<b>CHN-HAT</b>	<b>CHN-Recap</b>	<b>COHO</b>	<b>COHO-Recap</b>	<b>HYB</b>	<b>HYB-Recap</b>	<b>LMB</b>	<b>LND</b>	<b>SCP</b>	<b>SKB</b>	<b>SMB</b>	<b>STH</b>	<b>STH-HAT</b>	<b>STH-Recap</b>	<b>SUK</b>	<b>TF</b>	<b>WHF</b>
07/03/12	E-Fish		2		1			2		1									2			
07/03/12	Seine 1		1					4		1	1											
07/03/12	Seine 2		3					4														
08/03/12	E-Fish	1	1	1	3			3						14					3		1	1
08/03/12	Seine 1		5		21			19		3				85	1				1			3
08/03/12	Seine 2																					
09/06/12	E-Fish		2		6			1				1		44	2						2	
09/06/12	Seine 1		4	2	7		4	14	4					2					2			3
09/06/12	Seine 2			1					1													1
10/04/12	E-Fish				11		1	1		2	2		3	54		10				1		1
10/04/12	Seine 1			7	6		2	13	4					11						1		1
10/04/12	Seine 2													1								
11/08/12	E-Fish				2			2				1		27		13						
11/08/12	Seine 1			1	6	2		32	1		1			2						1		
11/08/12	Seine 2				5		1	11						1								
12/13/12	E-Fish		1		2		1	1						45					2		2	
12/13/12	Seine 1				6			7	1		1								1			
12/13/12	Seine 2		1		6	1	1	31			1			1				3	1	1	2	
<b>Total</b>		<b>1</b>	<b>20</b>	<b>12</b>	<b>82</b>	<b>3</b>	<b>10</b>	<b>145</b>	<b>11</b>	<b>7</b>	<b>6</b>	<b>2</b>	<b>3</b>	<b>287</b>	<b>3</b>	<b>23</b>	<b>14</b>	<b>1</b>	<b>3</b>	<b>1</b>	<b>7</b>	<b>10</b>

**Table 10. Mean number of days between tagging date and detection at TCM (presumed outmigration)**

Species	Mean # Days	Range	# Fish	Tagging Location
CCT	831	210 - 1,862	9	Above Highway 43 Culvert
CCT	22	8 - 36	2	Below Highway 43 Culvert
CHN	15	2 - 14	14	Below Highway 43 Culvert
CHN-HAT	--	--	4	Willamette Hatchery
CHN-HAT	11	--	1	Below Highway 43 Culvert
COHO	73	--	1	Above Highway 43 Culvert
COHO	45	4 - 78	35	Below Highway 43 Culvert
HYB	-24	-115* - 105	2	Below Highway 43 Culvert
STH	128	--	1	Below Highway 43 Culvert

\*TCM Detection before recapture below the Highway 43 culvert (Upstream movement).

## Findings

- Lamprey ammocoetes were found below the Highway 43 culvert in 2011; zero ammocoetes were found above the Highway 43 culvert in any year.
- There was no evidence of adult lamprey in any part of Tryon Creek in any year.
- The passage of fish from downstream locations to above the culvert confirms some ability of CCT, *O. mykiss*, and HYB upstream navigation through the culvert. There may be some maximum flow threshold in which upstream navigation through the culvert is not possible. It is possible a threshold for minimum flow exists as well.
- The only observation of adult anadromous salmonids was below the Highway 43 culvert.
- Salmonids collected during survey efforts yielded a number of *O. mykiss*, CCT, HYB, CHN and coho. CCT were the most abundant salmonid species above the Highway 43 culvert, coho were the most abundant salmonid species below the Highway 43 culvert.
- The two pass abundance estimate of trout (> 100 mm) above the Highway 43 culvert has ranged from  $613 \pm 42.30$  fish in 2008,  $748 \pm 44.18$  fish in 2009, and  $891 \pm 104$  in 2011. Abundance estimates have not changed significantly and suggest a stable population.
- Abundance estimates equate to a mean density across years of 150 trout/km. This density falls within the range of variability seen for several coastal cutthroat trout populations from coastal Oregon and British Columbia (Connolly and Hall 1999; Rosenfeld et al. 2000). De Groot (2004) estimated a mean summer density of 120 fish/km for coastal cutthroat trout across logged and unlogged streams.

- CCT, *O. mykiss*, and HYB were detected both leaving and entering Tryon Creek at the Highway 43 culvert. This may indicate the presence of a migratory component of the population. However, the majority of tagged coastal cutthroat have not been detected leaving the system, suggesting the resident form is dominant.
- No nonnative fish species have been captured above the Highway 43 culvert.
- The majority of coho and CHN were detected leaving Tryon Creek after residing in Tryon Creek for 15 – 45 days. This suggests habitat in Tryon Creek below the Highway 43 culvert may serve as a refuge for juvenile salmonids emigrating from elsewhere in the Willamette basin.

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