IMPACTS OF DAM AND RESERVOIR PASSAGE ON OUTMIGRATING JUVENILE HATCHERY CHINOOK SALMON: RESULTS FROM A PAIRED RELEASE STUDY IN THE UPPER WILLAMETTE RIVER BASIN

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Outplanting of adult spring Chinook salmon (*Oncorhynchus tshawytcha*) above Willamette Valley Project dams is currently taking place in the Middle Fork Willamette and North Santiam River basins to reintroduce these fish to their historic spawning grounds. These efforts have led to some natural production, but the impacts of Willamette Valley Project dams on the ability of juvenile salmonids to successfully outmigrate are not completely known. To help evaluate the effects of the dams on downstream passage, we present results from a four-year paired release study involving the release of juvenile PIT-tagged Chinook above and below dams on the Middle Fork Willamette and North Santiam rivers. Information gathered from PIT tag detections at Willamette Falls and other research projects in the Willamette and lower Columbia basins was used to assess differences in subsequent downstream detection, movement rate, timing, and growth for juvenile Chinook released above and below dams.

We released 665,283 PIT-tagged juvenile hatchery spring Chinook salmon (median 68 mm FL) in the Middle Fork Willamette and North Santiam rivers from 2011-2014. Fish were released into the Middle Fork Willamette River at Hills Creek Reservoir (HCR), Lookout Point (LOP) head of reservoir (HOR), LOP forebay (FB), LOP Dam tailrace (TR), and Dexter Dam TR. In the North Santiam River fish were released at Detroit HOR, Detroit FB, and Minto Dam TR. Additionally, 13,104 juvenile hatchery winter steelhead were released at Detroit HOR and Minto Dam TR in November 2014.

In total, 1.7% (N=7,465) of the Middle Fork Willamette and 2.7% (N=6,027) of the North Santiam juvenile hatchery Chinook have been detected at Willamette Falls through 16 December 2014. Except for 2014 Middle Fork Willamette Dexter TR and LOP TR and 2014 North Santiam TR and FB releases, detection proportions for juvenile hatchery Chinook released above and below dams differed significantly ($P<0.05$) from expected values with greater detection proportions observed for below-dam releases across years and basins. The magnitudes of differences were consistently greater in the Middle Fork Willamette River. In the Middle Fork Willamette (excluding HCR releases), detection proportion effect sizes for below-dam versus above-dam release comparisons ranged from 60-94% (Figure 1). In the North Santiam, detection proportion effect sizes for below-dam versus above-dam release comparisons ranged

from 15-39% (Figure 2). To date, none of the hatchery steelhead have been detected at Willamette Falls.

Movement rates (km/d) for below-dam released juvenile hatchery Chinook, in general, were significantly greater ($P<0.05$) than for above-dam releases of juvenile hatchery Chinook across years and basins. Movement rates for the 2011 Middle Fork Willamette HOR and 2013-2014 North Santiam FB release groups did not differ significantly from the respective TR release group movement rates in those years. Excluding the HCR release group, median movement rates for Middle Fork Willamette releases ranged from 5.4-6.2 km/d (2011), 4.7-5.8 km/d (2012), 3.6-6.2 km/d (2013), and 2.7-6.9 km/d (2014), while median movement rates for North Santiam releases ranged from 7.8-9.5 km/d (2012), 1.4-1.7 km/d (2013), and 2.2-2.5 km/d (2014) (Figures 3 and 4). Dam and reservoir impacts were also evident in outmigration timing; peaks in Willamette Falls detections occurred later for above-dam releases as compared to below-dam releases across basins and years (Figures 1 and 2).

Recapture and research-related mortality data were used to generate growth estimates (mm/d, FL) when length measurements were taken. Recaptures occurred during ODFW and USACE projects in the release basins, while ODFW research activities, particularly projects incorporating gillnets, were also major contributors to mortalities of study fish. Juvenile hatchery Chinook released above dams had significantly greater ($P<0.05$) growth rates than fish released below dams across years and basins, with the exception of the 2013 Middle Fork Willamette HCR and LOP TR release group growth rates which did not differ significantly from the respective TR release group growth rates in those years. A comparison of growth rates for above- and below-dam release groups was not possible for the 2013-2014 North Santiam releases, as none of the TR-released fish were recaptured or collected during research activities. Median growth rates for Middle Fork Willamette releases ranged from 0.7-0.7 mm/d (2011), 0.3-1.0 mm/d (2012), 0.5-0.9 mm/d (2013), and 0.2-0.9 mm/d (2014) (Figure 5). For the North Santiam releases, median growth rates ranged from 0.2-0.8 mm/d (2012), 0.7-0.7 mm/d (2013), and 0.8-0.9 mm/d (2014) (Figure 6).

Very few of the juvenile hatchery Chinook released for this study have returned as adults, with 11 of the Middle Fork Willamette releases and 6 of the North Santiam releases detected in the adult ladder at Willamette Falls. Three of the four adult returns from the 2011 releases were age-4 fish but only 0.03% of the 2011 releases have returned as adults. There have not been enough adult returns to detect a possible dam and reservoir effect on Chinook survival to adulthood, but to date HOR releases have produced more adult returns (N=10) than TR releases (N=7).

We demonstrated that, regardless of basin or year, fish released above dams were detected less frequently at Willamette Falls, suggesting substantial mortality is related to reservoir and dam passage. The difference in detection proportion effect sizes between basins suggests that the generalized effects of reservoir and dam passage are more substantial in the Middle Fork Willamette River than the North Santiam River. With our current methodology we can only speculate as to the specific sources of mortality, which are likely both directly (e.g., dam passage mortality) and indirectly (e.g., predation) related to the dams and reservoirs. Fish released above dams also exhibited slower movement to points downstream but grew faster than those released below the dams. Despite study limitations such as size of released fish and release

timing, we expect these data to be valuable in the further evaluation of survivorship trade-offs between rapid-growth reservoir rearing and direct dam passage mortality, with results becoming more useful as adult returns increase in the coming years.

Figure 1. Cumulative detections at Willamette Falls of PIT-tagged juvenile hatchery spring Chinook salmon released in the Middle Fork Willamette River. Release locations were Lookout Point (LOP) tailrace (TR), head of reservoir (HOR) and forebay (FB), Dexter TR, and Hills Creek Reservoir (HCR). Release dates in 2011 were 25 May for TR and 19 May for HOR, 25 May for all release locations in 2012, 31 May for all release locations in 2013, and 5 June for all release locations in 2014.

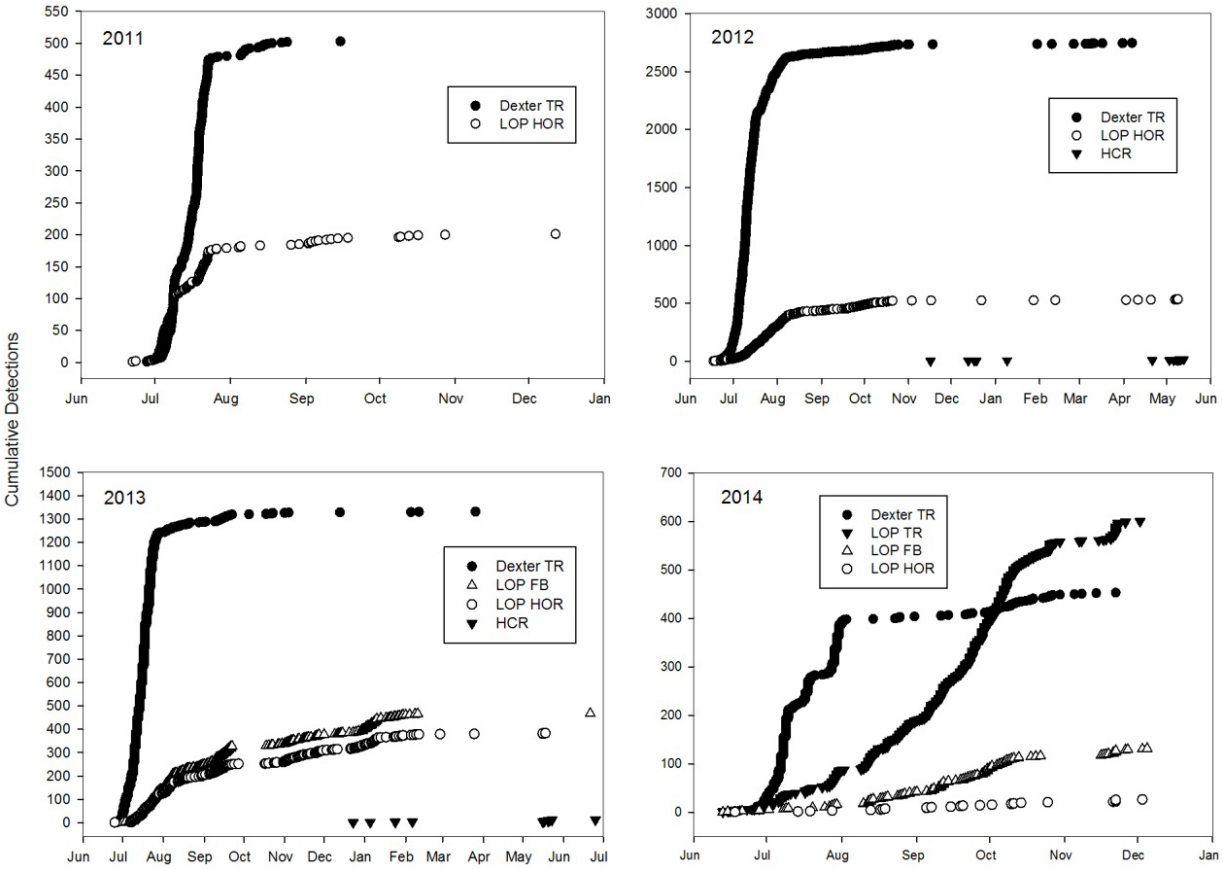

Figure 2. Cumulative detections at Willamette Falls of PIT-tagged juvenile hatchery spring Chinook salmon released into the North Santiam River. Release locations were Detroit head of reservoir (HOR) and forebay (FB), and Minto tailrace (TR), and release dates were 10 August 2012, 27 June 2013, and 9 July 2014.

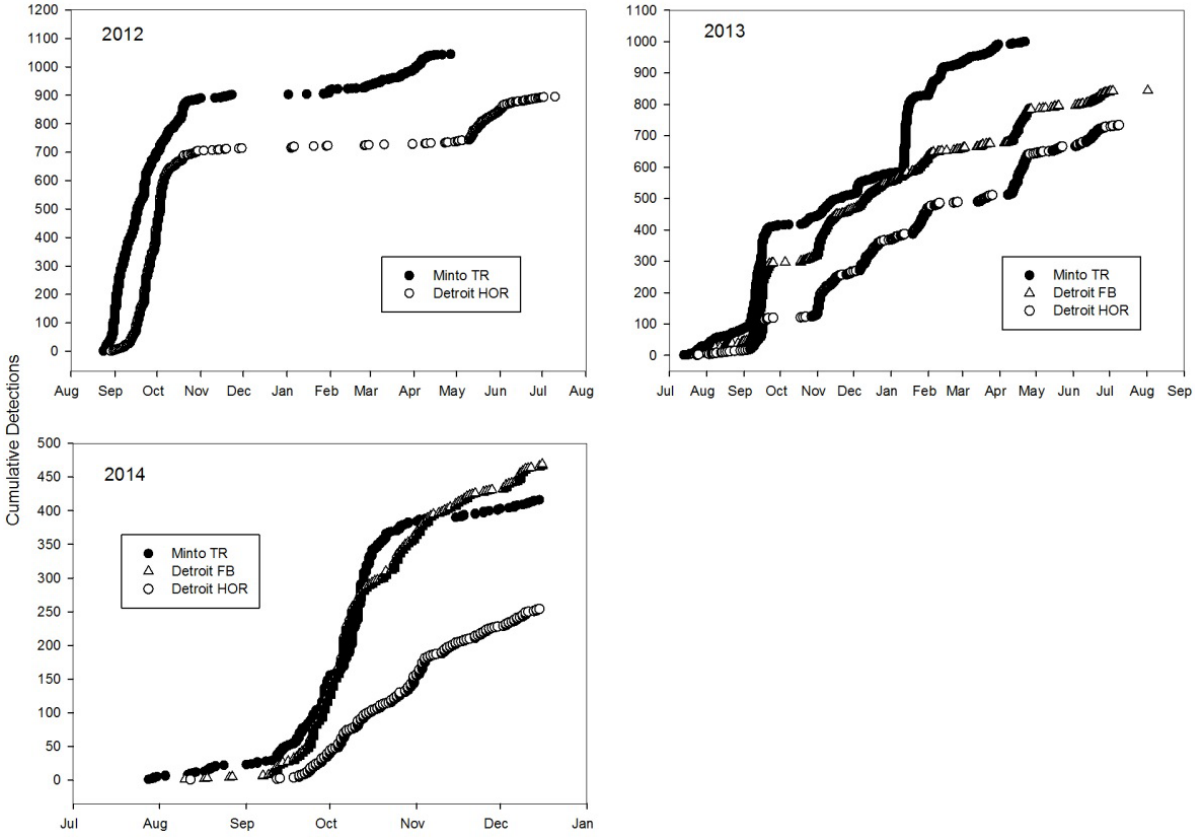

Figure 3. Movement rates (km/day) as determined from PIT tag detections at Willamette Falls of juvenile hatchery spring Chinook salmon released in the Middle Fork Willamette River at Lookout Point (LOP) tailrace (TR), head of reservoir (HOR) and forebay (FB), Dexter TR, and Hills Creek Reservoir (HCR). Release dates in 2011 were 25 May for TR and 19 May for HOR, 25 May for all release locations in 2012, 31 May for all release locations in 2013, and 5 June for all release locations in 2014.

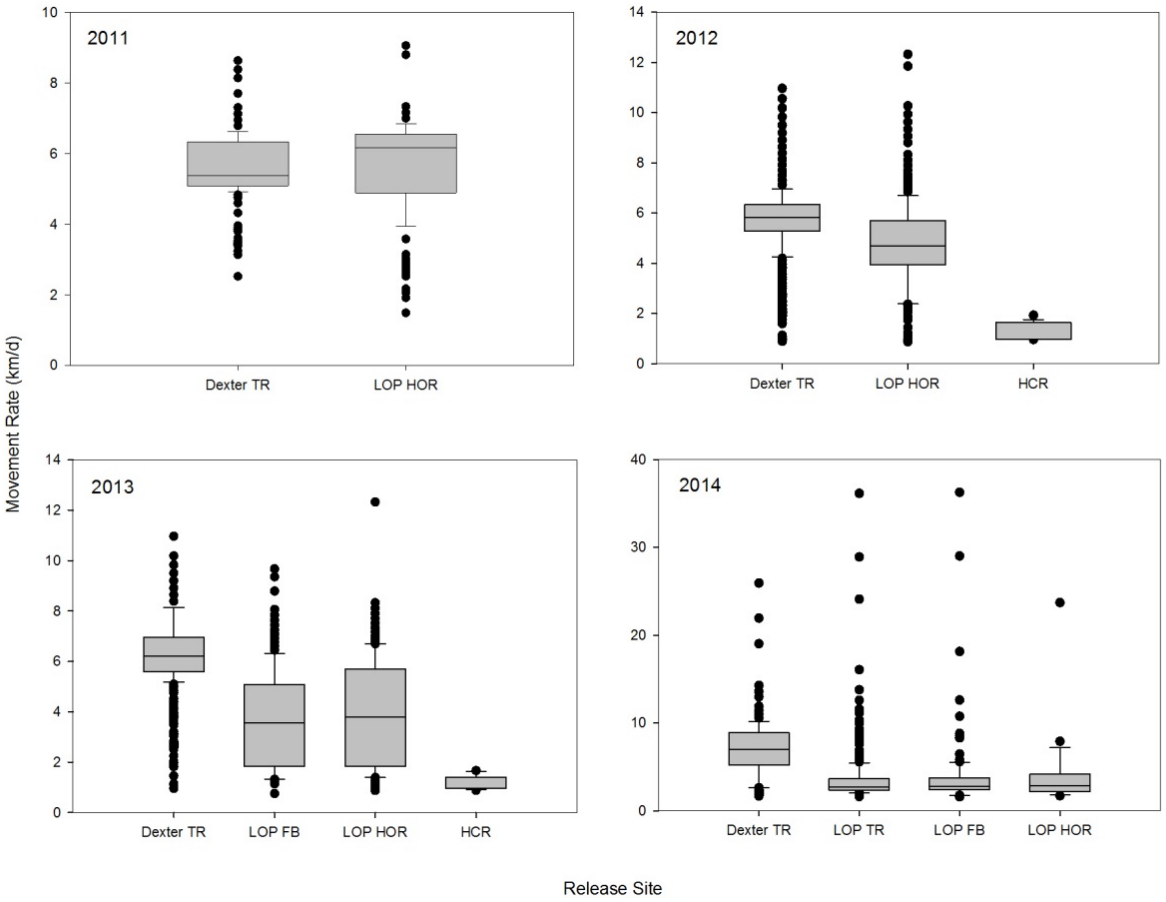

Figure 4. Migration rates (km/day) as determined from PIT tag detections at Willamette Falls of juvenile hatchery spring Chinook salmon released in the North Santiam River at Detroit head of reservoir (HOR) and forebay (FB), and Minto tailrace (TR). Release dates were 10 August 2012, 27 June 2013, and 9 July 2014.

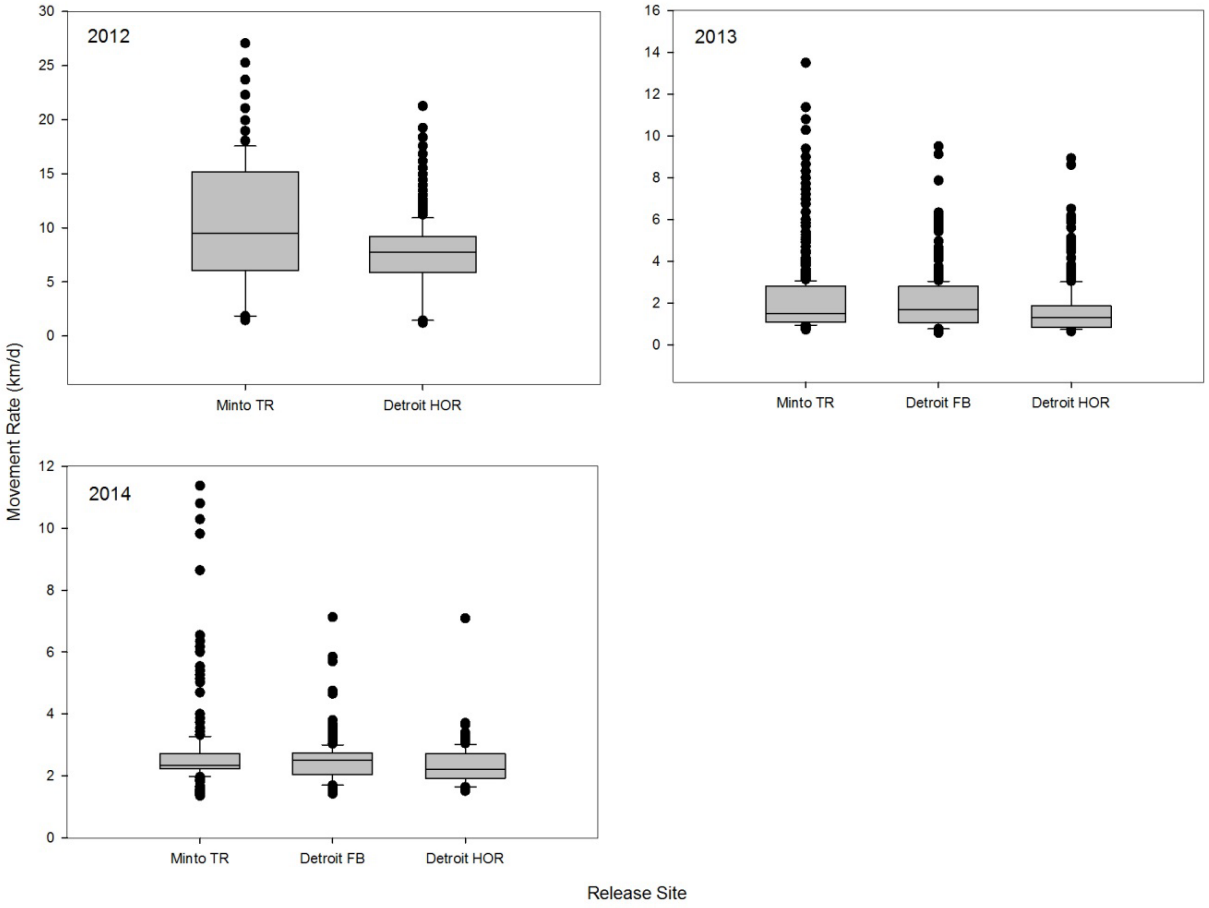

Figure 5. Growth rates (mm/day) as determined from recaptures and research-related mortalities of PIT-tagged juvenile hatchery spring Chinook salmon released in the Middle Fork Willamette at were Lookout Point (LOP) tailrace (TR), head of reservoir (HOR) and forebay (FB), Dexter TR, and Hills Creek Reservoir (HCR). Release dates in 2011 were 25 May for TR and 19 May for HOR, 25 May for all release locations in 2012, 31 May for all release locations in 2013, and 5 June for all release locations in 2014.

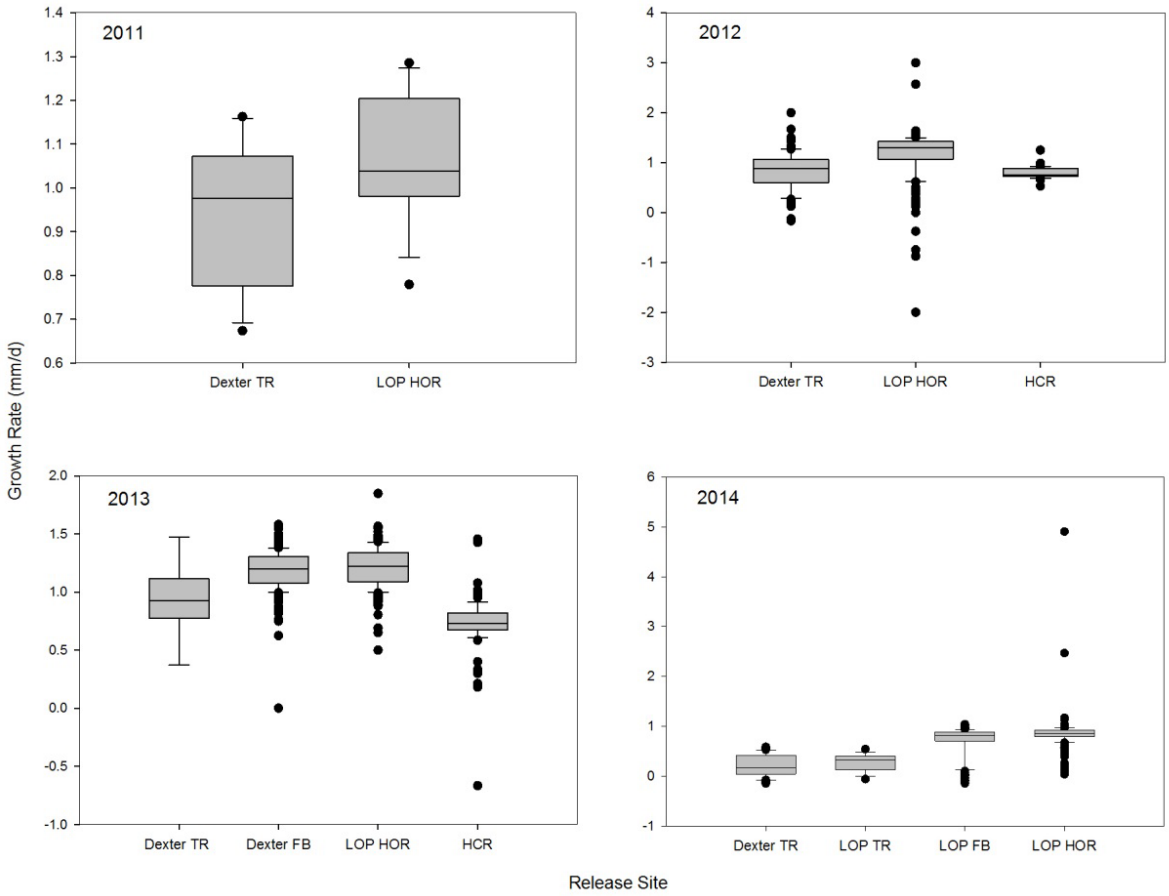
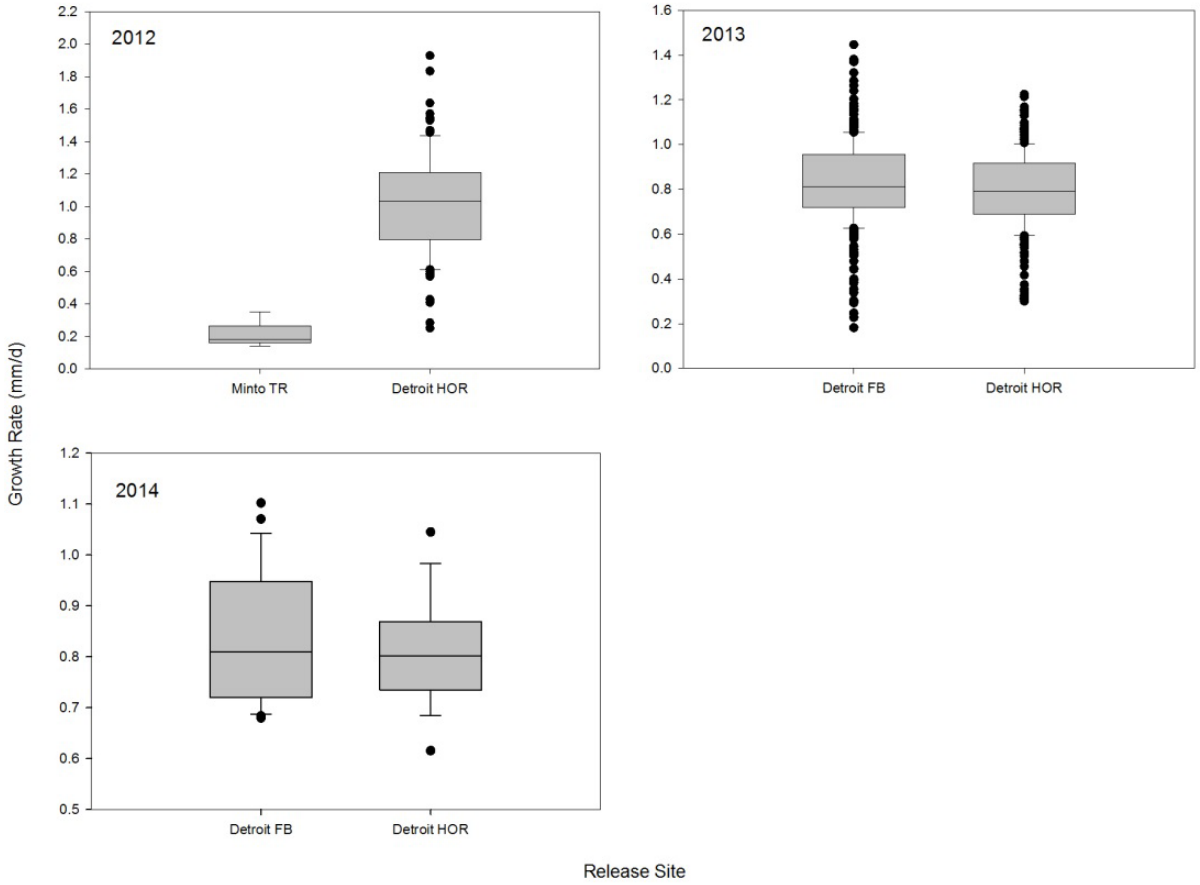
Figure 6. Growth rates (mm/day) as determined from recaptures and research-related mortalities of PIT-tagged juvenile hatchery spring Chinook salmon released in the North Santiam River at Detroit head of reservoir (HOR) and forebay (FB), and Minto tailrace (TR). Release dates were 10 August 2012, 27 June 2013, and 9 July 2014.