Lower Duwamish Waterway Group

Port of Seattle / City of Seattle / King County / The Boeing Company

JUVENILE CHINOOK SALMON DATA REPORT
FINAL

For submittal to

The US Environmental Protection Agency
Region 10
Seattle, WA

The Washington State Department of Ecology
Northwest Regional Office
Bellevue, WA

May 21, 2004

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Acronyms

Acronym	Definition
ARI	Analytical Resources, Incorporated
COC	chain of custody
DQI	data quality indicator
EPA	US Environmental Protection Agency
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
KCDNR	King County Department of Natural Resources
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
MDL	method detection limit
NMFS	National Marine Fisheries Service
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PSEP	Puget Sound Estuary Program
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RI	Remedial Investigation
RM	river mile
TBT	tributyltin

1.0 Introduction

This data report presents the results of the juvenile chinook salmon (*Oncorhynchus tshawytscha*) study conducted as part of the Phase 2 Remedial Investigation (RI) for the Lower Duwamish Waterway (LDW). This study was designed to collect representative whole-body tissue and stomach content samples from wild and hatchery juvenile chinook salmon for chemical analysis. Data collected for the present study will expand the set of LDW juvenile chinook salmon tissue data that have undergone quality assurance/quality control (QA/QC) review (EPA 2003) and are usable in the LDW Phase 2 RI. Data from this study will be used to support the following RI activities: 1) assessment of risks to juvenile chinook salmon using a critical tissue concentration and dietary approach, and 2) assessment of risks to piscivorous receptors of concern (ROCs) based on an estimated chemical dose from dietary items, including juvenile chinook salmon.

To meet the RI data needs, tissue samples were collected from two locations in the LDW: 1) a location at the downstream terminus of the LDW, and 2) a location in the middle portion of the LDW identified as having relatively higher sediment concentrations of polychlorinated biphenyls (PCBs). To provide background data, tissue samples were collected from the Green River upstream of the LDW and from the Soos Creek Hatchery. Whole-body tissue samples were analyzed for PCBs, organochlorine pesticides, and tributyltin (TBT). One composite stomach content sample was collected from the lower portion of the LDW, and was analyzed for polycyclic aromatic hydrocarbons (PAHs) and metals.

This report is organized into sections addressing field and analytical methods, chemical analysis results, and references. The text is supported by the following appendices:

- Appendix A – chain of custody forms
- Appendix B – field forms, logs and notes
- Appendix C – data validation reports
- Appendix D – data tables
- Appendix E – raw analytical laboratory data
- Appendix F – data management

2.0 Fish Collection and Sample Processing Methods

This section describes fish collection and sample processing methods used in May and June 2003. The fish collection section includes a description of the sampling areas as well as a summary of the collection methods and results of these efforts. The sample processing section describes the methods used to composite juvenile chinook salmon whole-body and stomach content samples. Additionally, the sample identification scheme and field deviations from the QAPP are presented. The field procedures used to collect the tissue samples are described in detail in the Quality Assurance Project Plan (QAPP): Juvenile Chinook Salmon Collection and Processing report (Windward 2003a). Copies of completed chain-of-custody forms used to track sample custody are presented in Appendix A. Photocopies of field forms and notebooks are presented in Appendix B.

Wild Puget Sound chinook salmon were listed as threatened under the Endangered Species Act in March 1999. As a threatened species, wild Puget Sound chinook salmon cannot be collected for analysis without a "take" permit issued by the National Marine Fisheries Service (NMFS). The collection of the wild juvenile chinook salmon in this study was authorized under two "take" permits: Permit 1314 (issued to the Port of Seattle), with an overall take limit of 190 fish from the LDW, and Permit 1309 (issued to King County), to get the fish from the upstream site not covered under Permit 1314. The wild juvenile chinook salmon collected for the present study represent only a portion of the fish that were allowed to be collected under these two permits. Agreements reached with the Port of Seattle and King County limited the number of wild juvenile chinook salmon that could be collected for the present study. The remaining fish that could be collected under these permits were previously allocated to other studies.

2.1 FISH COLLECTION

Table 2-1 and Figure 2-1 present the primary and alternative sample collection coordinates and areas along the LDW, as well as sampling locations along the Green River and Soos Creek Hatchery. The two primary locations in the LDW were Slip 4 (location MWa), and the downstream terminus of the LDW near Kellogg Island (location LWa). Location MWa was selected because sediment concentrations of PCBs in this area are generally higher relative to other areas in the LDW and because juvenile chinook salmon previously collected from this location by the National Marine Fisheries Service (NMFS 2002) had higher whole-body PCB concentrations relative to those collected near Kellogg Island. Location LWa was selected because, in theory, concentrations of chemicals in juvenile chinook salmon at the terminal end of their outmigration would reflect an integration of their exposure throughout the LDW site. This theory assumes that juvenile chinook salmon migrate through the LDW in a primarily downstream direction, and that they do not migrate back upstream to any significant extent once they reach the lower estuary. It is recognized, however, that little is known about the movement of juvenile chinook salmon within the LDW site.

Table 2-1. Juvenile chinook salmon sampling location coordinates

Station Location	Seine Transect				Point Location	
	Beginning		Ending			
	X	Y	X	Y	X	Y
LWa	1267190	208457	1267372	207783	na	na
LWb	1267024	209285	1267178	208953	na	na
LWc	1265985	210672	1266006	210204	na	na
LWd	1266766	207276	1267144	206877	na	na
MWa	1273364	198825	1273469	199298	na	na
MWb	1272885	198267	1272967	198118	na	na
MWc	1272282	198846	1272614	198665	na	na
MWd	1268008	204114	1267934	203954	na	na
Green River RM13	1290983	170658	1290774	170310	na	na
Green River RM18	na	na	na	na	1285942	153827
Soos Creek Hatchery	na	na	na	na	1308899	115017

na – not applicable; locations are either presented as the beginning and ending location of seining transect, or as a single point location for hatchery or screw trap (RM 18) samples.

RM – River Mile

Datum = Washington State Plane North, NAD83, US survey feet

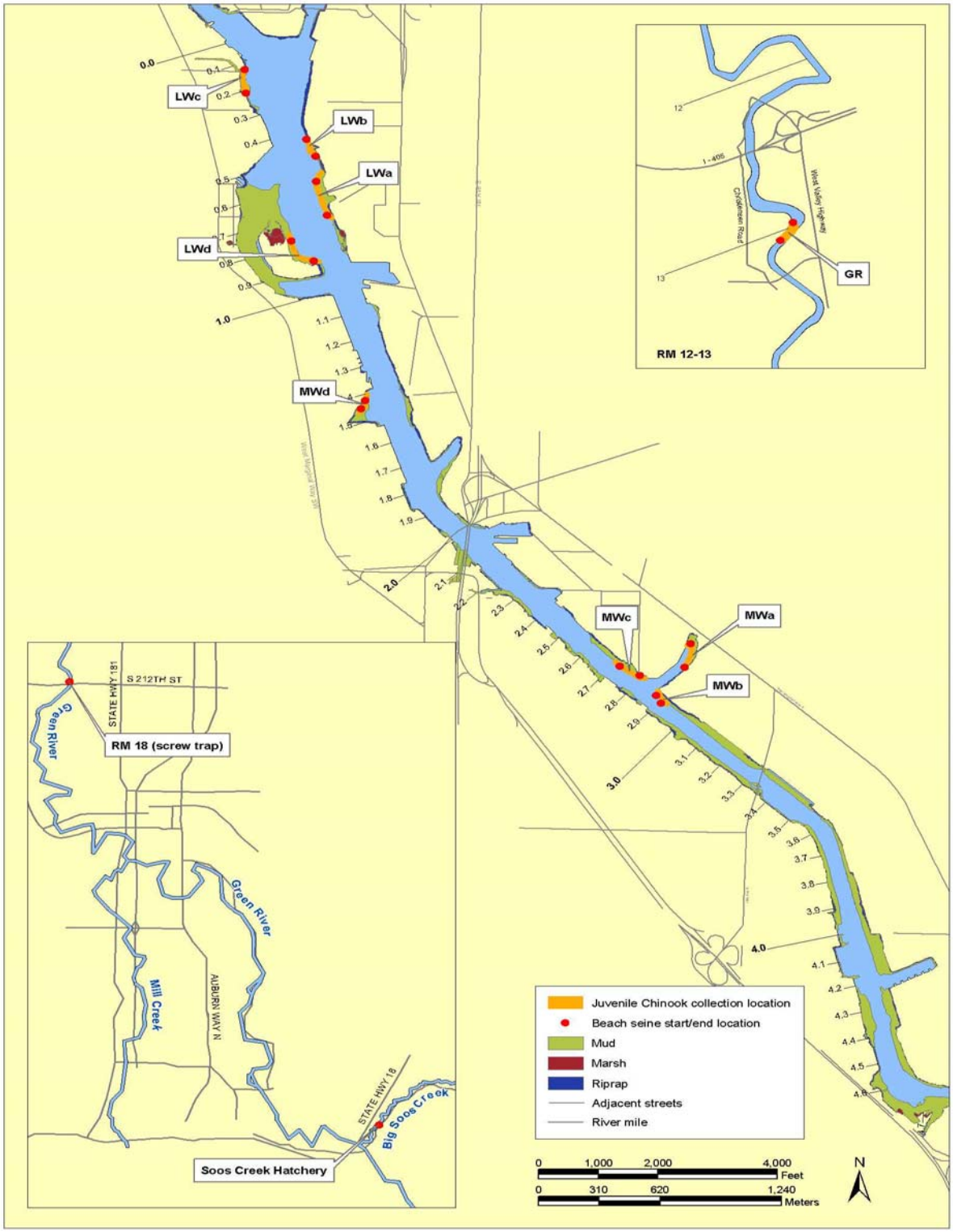

Figure 2-1. LDW and Green River juvenile chinook salmon sampling locations

Alternative locations, as described in the QAPP, were sampled when juvenile chinook salmon could not be collected at the primary locations. At the downstream terminus of the LDW, attempts were made to sample stations in the following order: LWa, LWb, LWc, LWd (Figure 2-1). At the stations in the middle of the LDW (i.e., around Slip 4), attempts were made to sample stations in the following order: MWa, MWb, MWc, MWd (Figure 2-1). Fishing continued at each subsequent station until enough individuals were caught or until three or fewer juvenile chinook salmon suitable for tissue analysis were captured in four consecutive attempts. Subsequent stations were sampled only when required to collect sufficient tissue for analysis. However, in some cases, due to the tidal stage, a beach was either too small or covered by water so a location had to be abandoned prior to four seining attempts (see Table 2-3).

Fish from the LDW and Green River, River Mile (RM)[1] 13, were captured in the field using a standard beach seine. Taylor and Associates assisted with sample collection in the LDW; the King County Department of Natural Resources (KCDNR) assisted with sample collection at RM 13 and RM 18. Fish from the hatchery were collected from a holding pond with a dip net. Fish were collected from RM 18 as an alternative location to RM 13 if a sufficient number of fish could not be collected from RM 13. These fish were captured in a screw trap set up by KCDNR.

Individual juvenile chinook salmon captured in the beach seine or screw trap were removed with a dip net and checked for a clipped adipose fin or presence of a coded wire tag to determine whether the fish was wild[2] or hatchery-raised. Fish were then placed in a 5-gal bucket filled with ice. Fish of similar size were preferentially selected. All fish were carefully inspected to ensure that the sampling equipment did not damage their skin or fins; damaged specimens were not accepted.

All individual specimens from a particular area were placed in one large Ziploc® bag, with the date and area recorded on the outside of the bag with indelible ink, and then placed in a cooler with ice. The iced fish were transported in coolers to Windward.

During the early May sampling event, juvenile chinook salmon were collected. These fish were all less than 100 mm in total length and all had intact adipose fins. The first reported release of fish from the Soos Creek Hatchery occurred on May 22, 2003. Hence, juvenile chinook salmon collected in May are assumed to be wild. During the June sampling, all juvenile chinook salmon with clipped adipose fins were identified as sub-yearling hatchery fish, and all juvenile chinook salmon with intact adipose fins and without coded wire tags were identified as wild fish. Other closely related fish that may have been present at that time included juvenile chum salmon, juvenile coho salmon, yearling hatchery chinook salmon, juvenile steelhead, and juvenile cutthroat trout. Species and origin (hatchery vs. wild) were verified by a Taylor and Associates

[1] River miles in this document are relative to the southern end of Harbor Island.

[2] A small percentage of hatchery fish are not clipped or tagged before release. Unclipped fish without coded wire tags collected in the June/July sampling event were not verified as wild.

fisheries biologist for LDW samples, and by Tom Nelson of King County for the Green River samples to ensure that only targeted species were composited for analysis.

2.1.1 May sampling

Seining was conducted in the LDW on May 12 and 13, 2003 at LWa, MWa, MWb, and MWc. Table 2-2 presents the number of wild chinook salmon caught in each seine at each station. In the lower waterway, all fish were captured from the primary location (LWa). In the middle waterway, a sufficient number of fish could not be captured from the primary location (MWa), so alternative locations (MWb and MWc) were also sampled.

Table 2-2. Numbers of wild juvenile chinook salmon caught during May seining

Station	May 12, 2003				May 13, 2003			Total Number of Fish
	Number of Sets	Number of Fish in 1st Set	Number of Fish in 2nd Set	Number of Fish in 3rd Set	Number of Sets	Number of Fish in 1st Set	Number of Fish in Remaining Sets	
LWa	3	12	4	11	0	nd	nd	27
MWa	3	0	5	0	2	5	2	12
MWb	0[a]	nd	nd	nd	5	0	3, 4, 0, 1	8
MWc	2	5	1	nd	2	0	1	7

[a] Tide was too high to deploy seines at MWb on May 12, 2003

nd – not deployed

2.1.2 June sampling

Seining was conducted in the LDW from June 23, 2003 to June 26, 2003 for collection of both whole body and stomach content samples. These dates were set in consultation with EPA staff who were interested in extending the date of the second sampling event as late as possible to prolong potential exposure of hatchery fish following their release. Both primary and alternative locations were sampled. In some cases, due to the tidal stage, a beach was either too small or was covered by water so alternative locations were seined before four seines could be completed at a given location. Table 2-3 presents the number of wild and hatchery salmon caught in each seine at each station.

Table 2-3. Numbers of hatchery[a] and wild[b,c] juvenile chinook salmon caught during June seining

Station	Number of sets[d]	Hatchery fish					Wild fish				
		Number of fish per set				Total	Number of fish per set				Total
		1st	2nd	3rd	4th or more		1st	2nd	3rd	4th or more	
June 23, 2003											
LWa	4	0	0	30	0	30	0	0	23	6	29
MWa	2	1	2	nd	nd	3	0	0	nd	nd	0
MWb	2	4	13	nd	nd	17	4	27	nd	nd	31
MWc	2	0	0	nd	nd	0	0	0	nd	nd	0
June 24, 2003											
LWa	2	2	4	nd	nd	6	0 (6)	0 (4)	nd	nd	0
LWd	2	1	0	nd	nd	1	0	0	nd	nd	0
MWa	2	0	0	nd	nd	0	0	0	nd	nd	0
MWb	5	0	0	4	0	4	0	0	0	0	0
MWc	1	0	nd	nd	nd	0	0	nd	nd	nd	0
MWd	1	0	nd	nd	nd	0	0	nd	nd	nd	0
June 25, 2003											
LWa	2	9	6	nd	nd	15	0 (8)	0 (10)	nd	nd	0
LWb	2	16	5	nd	nd	21	0 (5)	0	nd	nd	0
LWc	1	0	nd	nd	nd	0	0	nd	nd	nd	0
LWd	2	0	2	nd	nd	2	0 (2)	0 (1)	nd	nd	0
MWa	1	0	nd	nd	nd	0	0	nd	nd	nd	0
MWb	4	0	0	0	0 (1)	0	0	0	0	0	0
June 26, 2003											
LWa	7	0	5	2	4	11	0	0 (4)	0 (3)	0 (26)	0
LWb	3	15	0	1	nd	16	0 (16)	0 (1)	0 (2)	nd	0
LWd	1	2	nd	nd	nd	2	0 (2)	nd	nd	nd	0

[a] Number in parentheses is the number of hatchery fish that were caught but returned to the LDW because sufficient numbers of fish were not captured from MW stations for stomach content analysis

[b] Number in parentheses is the number of wild fish that were caught but returned to the LDW because the seines were deployed to catch hatchery fish for stomach content analysis

[c] Wild fish were collected from the LDW sites in May and June as part of one of the studies included in Permit 1314 (issued to the Port of Seattle) with an overall take limit of 190 wild fish. A small percentage of hatchery fish are not clipped or tagged before release. Unclipped fish without coded wire tags collected in the June/July sampling event were not verified as wild.

[d] Both hatchery and wild fish were caught in the same sets.

nd – not deployed because tide was too high or beach was not large enough to conduct an additional seine along the portion of beach undisturbed by previous seines on that day.

All wild fish for LW and MW whole-body composite samples were collected on June 23 at stations LWa and MWb (29 and 31 fish, respectively). All hatchery fish for the LW whole-body composite samples were collected on June 23 at LWa (30 fish).

Hatchery fish for the MW whole-body composite samples were collected from MWa on June 23 (3 fish) and from MWb on June 23 and 24 (17 and 4 fish, respectively).

Sufficient numbers of hatchery fish could not be collected at MW stations in late June in the time allotted in the QAPP to create a stomach content composite sample for MW locations. Therefore, following consultation with EPA, only one stomach content composite sample was obtained from hatchery fish collected from LW stations, rather than separate stomach content composite samples from the LW and MW stations, as specified in the QAPP (see Section 2.4). This composite sample was created from a total of 74 fish collected on June 24-26 at stations LWa, LWb, and LWd (Table 2-3).

Five hatchery and one wild fish were collected on June 18 in four seines at RM 13, but these fish were kept by King County to meet their study needs. Fishing was attempted at RM 13 by King County the following week on June 24, but no juvenile chinook salmon were caught in three sets. On June 24, King County moved upstream to RM 13.1 and collected four wild and seven hatchery chinook salmon in four sets. King County kept all but two of these hatchery fish to meet their study needs. Therefore, insufficient fish were available from RM 13 for whole-body or stomach content samples. Hatchery and wild chinook salmon were instead collected from the screw trap at Green River RM 18 on June 18, 19, 20, 24, and 25 (Table 2-7). A total of 22 wild fish and 22 hatchery fish were collected for whole-body composite samples from the screw trap. Three composite samples were created for each type of fish.

2.2 SAMPLE PROCESSING

Separate fish were collected for whole-body tissue analysis and for stomach content analysis. Fork lengths of individual fish for whole-body analysis were measured to the nearest millimeter and the individual fish were then weighed to the nearest 0.1 g at Windward's processing lab, individually wrapped in aluminum foil, and enclosed in individual Ziploc® bags with an identification label, also enclosed in a Ziploc® bag. The field coordinator reviewed the length and weight information and determined which fish to assign to each composite sample. Composite samples created in May and June are described in Sections 2.2.1 and 2.2.2, respectively. Table 2-4 summarizes the numbers of composite samples created from each sampling area. Individual and composite sample identifiers were entered on the specimen collection log sheet. Immediately after specimens were processed, they were stored in coolers supplied with ice or frozen blue ice. The coolers were delivered to Analytical Resources, Incorporated (ARI) for processing.

Table 2-4. Number of composite samples collected at each sampling area

	MAY				JUNE		
	MW	LW	SOOS CK HATCHERY	GREEN RIVER[a]	MW	LW	GREEN RIVER[a]
Wild fish whole-body	3	3		3	3	3	3
Hatchery fish whole-body			1		3	3	3
Hatchery fish stomach contents					nc	1	nc

[a] Collected at RM 13 in May, and RM 18 in June.

MW represents a middle waterway station; LW represents a lower waterway station (see Figure 1-1)

nc – not collected, although proposed in the original study design, for reasons presented in Section 2.4.

Stomachs of hatchery fish collected for stomach content analysis were surgically removed at Windward's processing lab. Individual fish were measured and weighed. Fish were cut from the anal vent to the head and the entire gastrointestinal tract removed. Each stomach was cut open and the gut contents carefully scraped to remove only ingested contents. Fullness of the gut and distinguishable prey contents were noted. Gut contents were weighed to the nearest 0.002 g and composited into one sample and placed in a glass jar. The composite sample was complete when the accumulated gut contents reached the minimum target mass of 15 g. The sample was placed in a freezer at Windward and then transported to ARI on ice the following day.

2.2.1 May composite samples

As summarized in Table 2-5, six whole-body composite samples (each consisting of nine individual fish) were formed from wild fish caught in the LDW in May (three from the one lower waterway station, and three from the three middle waterway stations combined). Total weights of the whole-body composite samples are presented in Table 2-5.

A total of 27 wild fish were collected by beach seine from the Green River at RM 13 on May 14, 2003. Three composite samples, each consisting of nine individual fish, were created from fish collected at the Green River location. A total of 21 hatchery fish were collected from the holding pond at the Soos Creek Hatchery on May 31, 2003. One composite sample, consisting of 12 fish, was created from fish collected at the Soos Creek Hatchery, in accordance with the QAPP. Total weights of hatchery fish collected and weights of composite samples are presented in Table 2-5.

Table 2-5. Summary of May whole-body composite samples

Location (Station)	Date Collected	# of Seines	# of Fish per Composite Sample	Arithmetic Mean Weight (±SD) per Fish (g)	Weight per Composite Sample (g)
Lower Waterway (LWa) Wild					
Composite 1	May 12	1	9	2.63 (±0.60)	23.7
Composite 2	May 12	1	9	2.56 (±0.51)	23.0
Composite 3	May 12	1	9	2.52 (±1.16)	22.7
Middle Waterway (MWa,b,c)[a] Wild					
Composite 1[b]	May 12, 13	5	9	3.19 (±1.07)	28.7
Composite 2[c]	May 13	5	9	2.90 (±1.24)	26.1
Composite 3[d]	May 12, 13	4	9	3.03 (±2.09)	27.3
Green River (RM13) Wild					
Composite 1	May 14	2[e]	9	2.04 (±0.55)	18.4
Composite 2	May 14	2[e]	9	2.10 (±0.82)	18.9
Composite 3	May 14	2[e]	9	2.18 (±0.43)	19.6
Soos Creek Hatchery[f]					
Composite 1	May 21	na	12	3.13 (±0.75)	37.6

[a] 12 fish from MWa, 8 from MWb, 7 from MWc

[b] Contained 9 fish from MWa

[c] Contained 1 fish from MWa, 8 from MWb

[d] Contained 2 fish from MWa, 7 from MWc

[e] Collected by KCDNR at RM 13; KC made 3 sets (as required by their study design), but they captured the fish needed for this study in 2 sets

[f] Hatchery fish were collected from the holding pond with a dip net

na – not applicable

SD – standard deviation

2.2.2 June composite samples

As summarized in Table 2-6, 12 whole-body composite samples were formed from fish caught in the LDW in June (three hatchery fish composite samples and three wild fish composite samples at each of the LW and MW locations). The total weights of the whole-body composite samples are presented in Table 2-6. Composite samples within each of the three groups were formed so that the total weight of each composite sample was at least 50 g and sample sizes were within 20% of each other. A total of 22 wild fish and 22 hatchery fish were collected for whole-body composite samples from the screw trap at RM 18 in June. Three composite samples (weighing from 45.9 to 53.5 g) were created for each type of fish (Table 2-6).

Table 2-6. Summary of June whole-body composite samples

Location (Station)	Date Collected	# of Seines	# of Fish per Composite Sample	Arithmetic Mean Weight (±SD) per Fish (g)	Weight per Composite Sample (g)
Lower Waterway (LWa) Wild					
Composite 1	June 23	4	9	7.67 (±2.16)	69.0
Composite 2	June 23	4	9	7.20 (±1.62)	64.8
Composite 3	June 23	4	10	6.66 (±1.15)	66.6
Lower Waterway (LWa) Hatchery					
Composite 1	June 23	4	9	7.90 (±2.14)	71.1
Composite 2	June 23	4	9	7.77 (±2.13)	69.9
Composite 3	June 23	4	10	7.36 (±2.04)	73.6
Middle Waterway (MWb) Wild					
Composite 1	June 23	2	9	7.76 (±1.05)	69.8
Composite 2	June 23	2	9	7.01 (±1.65)	63.1
Composite 3	June 23	2	9	7.29 (±1.98)	65.6
Middle Waterway (MWa,b) Hatchery					
Composite 1[a]	June 23, 24	7	8	6.41 (±1.53)	51.3
Composite 2[b]	June 23, 24	7	8	6.48 (±1.46)	51.8
Composite 3[c]	June 23, 24	7	8	6.53 (±1.48)	52.2
Screw Trap (RM 18)[d] Wild					
Composite 1	June 18	na	7	6.56 (±0.95)	45.9
Composite 2	June 18, 19, 20	na	8	6.35 (±1.82)	50.8
Composite 3	June 24, 25	na	7	7.31 (±1.56)	51.2
Screw Trap (RM 18) Hatchery					
Composite 1	June 18	na	8	6.69 (±1.22)	53.5
Composite 2	June 19	na	7	7.39 (±0.65)	51.7
Composite 3	June 20	na	7	7.37 (±1.32)	51.6

[a] Contained 3 fish from MWa and 5 from MWb

[b] Contained 8 fish from MWb

[c] Contained 1 fish from MWa and 7 from MWb

[d] Wild fish were collected at upstream locations (RM 13 and 18) under Permit 1309 (issued to King County).

na – not applicable

SD – standard deviation

2.2.3 June stomach content composite sample

A composite sample was created from a total of 74 fish collected on June 24-26 at LWa, LWb, and LWd stations (Table 2-3). The composite sample of stomach contents from these fish weighed 15.48 g. The average weight of fish collected, prior to removal of stomach contents, was 7.71 g.

2.3 SAMPLE IDENTIFICATION SCHEME

Unique alphanumeric sample numbers were assigned to each individual fish and each composite sample. The first three characters are "LDW" to identify the Lower Duwamish Waterway project. The next two characters identify the specific sampling area: "LWa," "LWb," "LWc," or "LWd" for the Lower Waterway locations a-d; "MWa," "MWb," "MWc," or "MWd" for mid waterway locations a-d; "GR" for those collected at RM 13 of the Green River; and "RM 18" for those collected at RM 18 of the Green River. Following these identifiers, "H" or "W" designates hatchery or wild fish. The next identifier is either "SC" or "WF" for stomach contents or whole fish, followed by "comp" to indicate a composite sample, a sample number (i.e., 1, 2, or 3). For wild fish collected in LW locations, a letter to designate May (a) or June (b) collection was also added.[3] For example, the sample identifier LDW-LWa-W-WF-Comp1a represents a composite sample formed from wild fish collected from lower waterway location "a" in May. Each individual fish was assigned a unique alphanumeric sample number as described above, and was also a part of a composite sample. The compositing scheme accompanied the fish to the analytical laboratory and specified which individual fish to include in each composite sample.

2.4 FIELD DEVIATIONS FROM THE QAPP

Field deviations from the QAPP included modifications to composite weights, collection date, collection locations, and a processing method. These field deviations did not affect the data quality and are discussed in detail below. EPA was consulted on deviations that had a significant effect on study design (e.g., the decision to abandon MW locations for collection of fish for stomach contents).

- For May samples, there was a concern that whole-body composite samples might not be of sufficient weight for all of the analytes of interest, so the samples were frozen and sample compositing was put on hold until the issue was resolved. In May, each composite sample weighed 18 to 29 g rather than the 50 g specified in the QAPP. A higher sample mass was not collected because of concerns with permit limitations on the total number of wild fish allowed for capture in May and June. Therefore, preference was given to obtaining similar

[3] The final "a" or "b" to designate sampling month was added in the data validation stage to facilitate identification in the database of wild fish composite samples collected from the LW locations. The samples were easily distinguished by their unique date and time to make this distinction.

weights among the three composite samples within each location rather than using similarly sized fish within each composite, as specified in the QAPP.

- Collection of fish from the Soos Creek Hatchery was planned for May 15, 2003, but because the fish were sick on that day, sampling was postponed until May 21, 2003.
- In some cases, due to the tide, a beach was either too small or covered by water, so alternate locations were sampled in the order designated in the QAPP prior to four seining attempts.
- Insufficient fish were available from RM 13 for whole-body or stomach content analyses during the June sampling event. Instead, hatchery and wild chinook salmon were collected from the screw trap at RM 18. Three fish captured in the screw trap were examined for stomach contents; total contents from their stomachs weighed 0.06 g. This relatively small amount was likely attributable to the presence of those fish in the screw trap for up to 24 hrs with little or nothing to eat; it was subsequently concluded that fish collected from the screw trap could not be used to collect sufficient mass for analysis of stomach contents of upstream fish.
- Seining in the LDW for stomach content analysis was conducted from June 24 to June 26, 2003 at LW locations. Five seining attempts were made at the MW locations on June 25 but only one fish was collected. Based on consultations with EPA, MW was abandoned for collection of fish for stomach contents. Therefore, no stomach content sample was collected at the MW locations, and the collection effort was redirected to the LW locations, primarily LWa and LWb, the sites with the greatest catch.
- Fish collected for stomach contents were killed on ice and processed at Windward rather than being killed by severing the spinal column just behind the head and being processed in the field, as indicated in the QAPP. This deviation occurred to focus personnel effort on collecting as many fish as possible during the four days allocated.

3.0 Laboratory Methods

The methods and procedures used to analyze the tissue samples are described in detail in the Quality Assurance Project Plan (QAPP): Collection and Analysis of Juvenile Chinook Salmon (Windward 2003b). ARI homogenized and froze each whole-body composite sample. ARI then transported all samples frozen and in coolers with ice to Columbia Analytical Services (CAS). CAS analyzed the whole-body composite samples for percent solids, percent lipids, TBT, PCBs as Aroclors, and DDTs and other organochlorine pesticides. The composite stomach content sample was homogenized at CAS just prior to chemical analysis. The composite stomach content sample was analyzed for metals (except mercury), PAHs, and alkylated PAH

homologues. Laboratory SOPs for tissue homogenization are presented in Appendix B of the QAPP.

3.1 ANALYTICAL METHODS

Analytical testing adhered to the most recent EPA quality assurance and quality control guidelines and analysis protocols (PSEP 1997; EPA 2002). To achieve the targeted detection limits (Table 3-1), tissue and stomach contents samples analyzed for organic analytes were soxhlet extracted and submitted for gel permeation chromatography as well as florisil and/or silica gel columns to remove lipids and other potential sources of analytical interference. The methods of chemical analysis are identified in Table 3-1. All methods selected represent standard methods used for the analysis of these analytes in tissue.

Table 3-1. Analytical methods for whole body and stomach content analyses

PARAMETER	UNIT	METHOD	REFERENCE
PCBs as Aroclors[a]	µg/kg ww	GC/ECD	EPA 8082
DDTs and other organochlorine pesticides[a,b]	µg/kg ww	GC/ECD	EPA 8081A
PAHs (and alkylated PAH homologues)[c,d]	µg/kg ww	GC/MS	EPA 8270C SIM[e]
Arsenic[c]	mg/kg ww	ICP-MS	EPA 6020
Cadmium[c]	mg/kg ww	ICP-MS	EPA 6020
Chromium[c]	mg/kg ww	ICP-AES	EPA 6010B
Copper[c]	mg/kg ww	ICP-MS	EPA 6020
Lead[c]	mg/kg ww	ICP-MS	EPA 6020
Silver[c]	mg/kg ww	ICP-MS	EPA 6020
Zinc[c]	mg/kg ww	ICP-MS	EPA 6010B
TBT[a]	µg/kg ww	GC/FPD	Stallard et al. (1988)
Lipids[a]	% ww	gravimetric	NOAA (1993)
Moisture[a,c]	% ww	freeze dried	PSEP (1997)

[a] Analyte only for whole-body composite samples

[b] Target pesticides include: 4,4'-DDT, 4,4'-DDE, 4,4'-DDD, 2,4'-DDT, 2,4'-DDE, 2,4'-DDD, dieldrin, aldrin, cis- and trans- nonachlor, oxychlordane, cis-and trans-chlordane, mirex, and toxaphene

[c] Analyte only for stomach content composite samples

[d] Target PAHs include: anthracene, pyrene, dibenzofuran, dibenzothiophene, benzo(g,h,i)perylene, benzo(e)pyrene, indeno(1,2,3-cd)pyrene, perylene, benzo(b)fluoranthene, fluoranthene, benzo(k)fluoranthene, acenaphthylene, chrysene, benzo(a)pyrene, dibenzo(a,h)anthracene, benzo(a)anthracene, acenaphthene, phenanthrene, fluorene, 1-methylnaphthalene, naphthalene, 2-methylnaphthalene, and biphenyl. Target alkylated PAH homologs include: C1-chrysenes, C2-chrysenes, C3-chrysenes, C4-chrysenes, C1-dibenzothiophenes, C2-dibenzothiophenes, C3-dibenzothiophenes, C1-fluoranthenes/pyrenes, C1-fluorenes, C2-fluorenes, C3-fluorenes, C1-phenanthrenes/anthracenes, C2-phenanthrenes/anthracenes, C3-phenanthrenes/anthracenes, C4-phenanthrenes/anthracenes, C2-naphthalenes, C3-naphthalenes, C4-naphthalenes

[e] Alkylated PAHs were analyzed using a laboratory SIM method that differed substantially from EPA 8270C SIM (see Section 3.2)

FPD – flame photometric detection
GC – gas chromatography
ICP – Inductively coupled plasma emission spectrometry
MS –mass spectrometry
SIM – select ion monitoring
ww – wet weight basis

3.2 LABORATORY DEVIATIONS FROM THE QAPP

Minor deviations from the QAPP included slight modifications in handling and processing of samples, and the use of different methods for solids and lipids analysis. EPA sample handling protocols were not compromised as a result of handling and processing methods, and the alternative laboratory methods were either preferable or comparable to those specified in the QAPP. Therefore, the data quality is not affected by these deviations discussed in detail below.

- The QAPP stated that fish would be delivered to ARI within 24 hrs of processing. Fish from both May and June were frozen individually and stored in Windward's freezer after processing (weighing and measuring) until all sampling, subsequent decisions regarding the compositing scheme, and compositing were complete. All fish collected in May were delivered to ARI immediately following compositing. Compositing of fish collected in June was completed on June 25, 2004, but frozen fish were not delivered to ARI until June 27, 2003, where they were kept frozen until homogenization. Because of workload capacity constraints at ARI, homogenization of all whole-body composite samples occurred on July 1, 2003 rather than 24 hrs after receipt.
- The stomach contents sample was composited at Windward on June 24, 25, and 26th, 2003 and frozen each day until the final composite was delivered to ARI in a cooler on ice on June 27th, 2003. The stomach contents sample was kept frozen at ARI until it was shipped to CAS on ice.
- A final "a" or "b" was added to sample identification schemes during the data validation stage to designate the month in which wild fish were sampled from LW samples.
- The stomach content sample was not homogenized at ARI, but was instead homogenized at CAS just prior to chemical analysis. This delay in homogenization was recommended by ARI to better preserve the integrity and mass of the sample prior to analysis. EPA sample handling protocols were followed at all times.
- The QAPP references EPA Method 8270C SIM as the analytical method for PAH. However, the quantitation method used for alkylated PAH homologs is significantly different from Method 8270C and is better described as a laboratory in-house method. A detailed discussion of this issue is presented in Appendix C.
- Total solids were analyzed by a freeze-dry method, although the project QAPP specifies EPA Method 160.3. However, Method 160.3 is a soil/sediment method and freeze-drying is the appropriate method for tissue samples.
- Total lipids were analyzed by the NOAA (1993) method, although the project QAPP specified Bligh and Dyer (1959). These methods are comparable for tissue matrices. The solvent properties of the mixture of methanol and

chloroform specified in Bligh and Dyer (1959) are similar to those of the mixture of sodium sulfate and dichloromethane used with the PSEP method and no qualifiers were assigned based on the different analytical method.

4.0 Chemical Analysis Results

Results of the whole-body tissue and stomach contents chemical analyses are summarized in this section. These results were received from CAS and have been validated by Sayler Data Solutions, Inc. Complete data tables and raw laboratory data can be found in Appendices D and E, respectively. When laboratory replicates were analyzed, the average concentration for the replicates was calculated and used as the sample concentration. A detailed discussion of the approach used in averaging laboratory replicates is presented in Appendix F. Methods for calculating total concentrations for PCBs, PAHs, and DDTs are also presented in Appendix F.

Quality assurance review of the chemistry data was conducted in accordance with the QA/QC requirements and technical specifications of the methods, and the National Functional Guidelines for Organic and Inorganic Data Review (EPA 1999, 2002). Sayler Data Solutions conducted a full data validation of the analytical results. No data were rejected as a result of the data validation; all data were determined to be acceptable for use as qualified. The results of the data validation are discussed in Sections 4.1.5 and 4.2.2 for whole-body tissues and the stomach content sample, respectively, and presented in full in Appendix C.

4.1 WHOLE-BODY TISSUE RESULTS

Whole-body juvenile chinook salmon tissue samples were analyzed for PCBs, organochlorine pesticides, TBT, lipids, and percent solids. The results of these analyses are discussed separately below.

4.1.1 Total PCBs

Total PCBs were based on the sum of detected Aroclors 1242, 1254, and 1260. All other Aroclors were undetected. PCBs were detected in all whole-body composite samples, except for two composite samples collected from the Green River in May, as shown in Table 4-1. The detection limits reported for total PCBs for these two samples were based on the highest detection limit for an individual Aroclor. Total PCB concentrations in individual whole-body composite samples ranged from 5.8 to 1200 µg/kg ww and lipid normalized concentrations ranged from 0.28 to 170 mg/kg lipid . Mean total PCB concentrations per location ranged from 6.2 to 660 µg/kg ww in wild fish collected in May and June (Figure 4-1) and from 9.5 to 120 µg/kg ww in hatchery fish collected in June.

Table 4-1. Total PCB concentrations in juvenile chinook salmon whole-body composite samples

Location	Composite	Total PCB Concentration (µg/kg ww)								Lipid-normalized Total PCB concentration (mg/kg lipid)							
		Wild				Hatchery				Wild				Hatchery			
		May	Qual	June	Qual	May	Qual	June	Qual	May	Qual	June	Qual	May	Qual	June	Qual
Lower Waterway (LW)	1	190	J	9.3	J	nc		14	J	35	J	0.62	J	nc		1.0	J
	2	300[a]	J	21[a]		nc		38		3.0	J	1.2		nc		3.2	
	3	320	J	30	J	nc		18	J	29	J	3.0	J	nc		1.1	J
Mean ± SD		270 ± 70		20 ± 10				23 ± 13		22 ± 17		1.6 ± 1.2				1.8 ± 1.2	
Middle Waterway (MW)	1	1,200		6.9	J	nc		141	J	170		0.25	J	nc		12	J
	2	500	J	10	J	nc		36	J	51	J	0.71	J	nc		2.6	J
	3	290	J	20	J	nc		170	J	22	J	0.74	J	nc		11	J
Mean ± SD		660 ± 480		12 ± 6.8				120 ± 71		81 ± 78		0.57±0.27				8.5 ± 5.2	
Green River [b] (GR)	1	500	J	6.3	J	nc		9.8	J	38	J	0.39	J	nc		0.89	J
	2	31	U	6.6	J	nc		9.5	J	2.4	U	0.37	J	nc		0.95	J
	3	17	U	5.8	J	nc		9.3	J	2.0	U	0.28	J	nc		0.72	J
Mean ± SD		180 ± 270		6.2 ± 0.40				9.5 ± 0.25		14 ± 21		0.35±0.059				0.85±0.12	
Soos Creek (SC)	1	nc		nc		85	J	nc		nc		nc		2.4	J	nc	

[a] Result represents the average of two laboratory duplicates

[b] Collected at RM 13 in May and RM 18 in June

J – Estimated value

U – PCBs were analyzed for, but were not detected at or above the stated detection limit

nc – not collected

SD – standard deviation

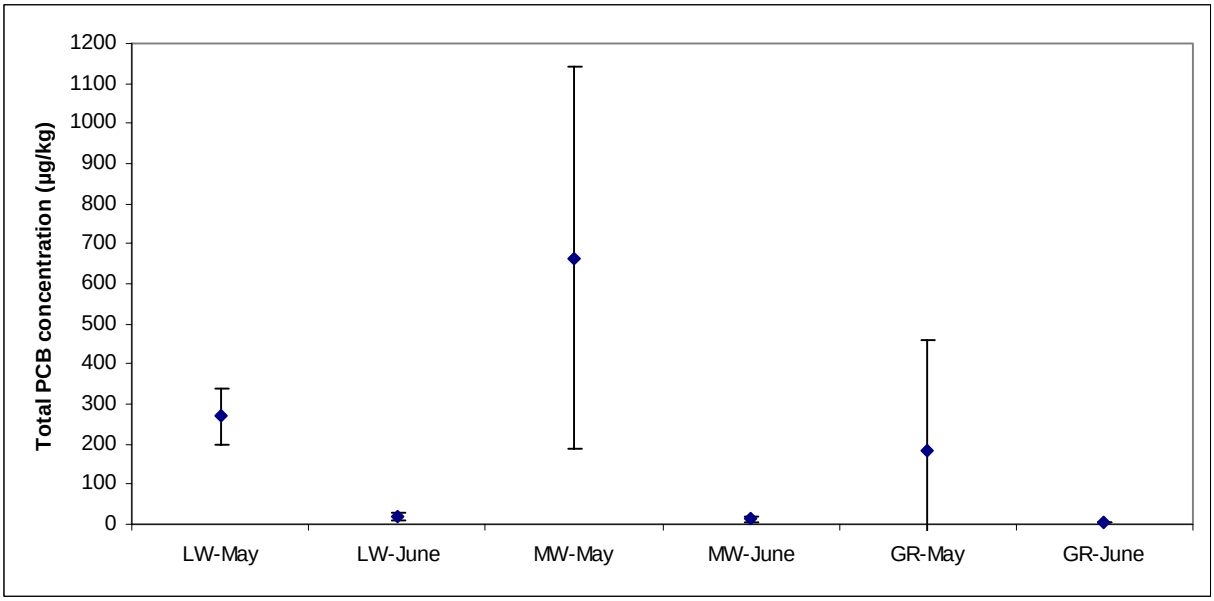

Figure 4-1. Mean total PCB concentrations and standard deviations for wild juvenile chinook salmon whole-body composite samples

4.1.2 Organochlorine pesticides

Total DDTs were detected in all whole-body composite samples, at concentrations ranging from 1.4 to 87 µg/kg ww and lipid normalized concentrations ranging from 0.08 to 12.4 mg/kg lipid (Table 4-2). Mean total DDT concentrations per location ranged from 3.8 to 65 µg/kg ww in wild fish collected in May and June (Figure 4-2) and from 6.9 to 10 µg/kg ww in hatchery fish collected in June.

Table 4-2. Total DDT concentrations[a] in juvenile chinook salmon whole-body composite samples

		Total DDT Concentration (µg/kg ww)								Lipid-normalized Total DDT concentration (mg/kg lipid)							
		Wild				Hatchery				Wild				Hatchery			
Location	Composite	May	Qual	June	Qual	May	Qual	June	Qual	May	Qual	June	Qual	May	Qual	June	Qual
Lower Waterway (LW)	1	38	J	6.8	J	nc		8.2	J	6.9	J	0.45	J	nc		0.59	J
	2	54	J	1.4	J	nc		13.9	J	5.4	J	0.08	J	nc		1.2	J
	3	71[b]	J	12[b]	J	nc		7.7	J	6.5	J	0.71	J	nc		0.45	J
Mean ± SD		54 ± 17		6.7 ± 5.3				9.9 ± 3.4		6.3 ± 0.78		0.41±0.32				0.75±0.40	
Middle Waterway (MW)	1	87		4.7	J	nc		4.2	J	12		0.17	J	nc		0.35	J
	2	56	J	2.5	J	nc		10.9	J	5.7	J	0.18	J	nc		0.78	J
	3	53	J	4.1	J	nc		20	J	4.1	J	0.15	J	nc		1.33	J
Mean ± SD		65 ± 19		3.8 ± 1.2				10 ± 8.0		7.3 ± 4.2		0.17±0.015				0.82±0.49	
Green River[c] (GR)	1	82	J	3.5		nc		5.7	J	6.3	J	0.22		nc		0.52	J
	2	10.1	J	5.6	J	nc		8.3	J	0.78	J	0.31	J	nc		0.83	J
	3	15.7	J	4.7	J	nc		6.6	J	1.9	J	0.22	J	nc		0.51	J
Mean ± SD		36 ± 40		4.6 ± 1.1				6.9 ± 1.3		3.0 ± 2.9		0.25±0.052				0.62±0.18	
Soos Creek (SC)	1	nc		nc		16.1	J	nc		nc		nc		0.46	J	nc	

[a] Total DDT is the sum of detected concentrations of 4,4'-DDT, 4,4'-DDE, 4,4'-DDD, 2,4'-DDT, 2,4'-DDE, and 2,4'-DDD

[b] Result represents the average of two laboratory duplicates

[c] Collected at RM 13 in May and RM 18 in June

SD – standard deviation

J – Estimated value

nc – not collected

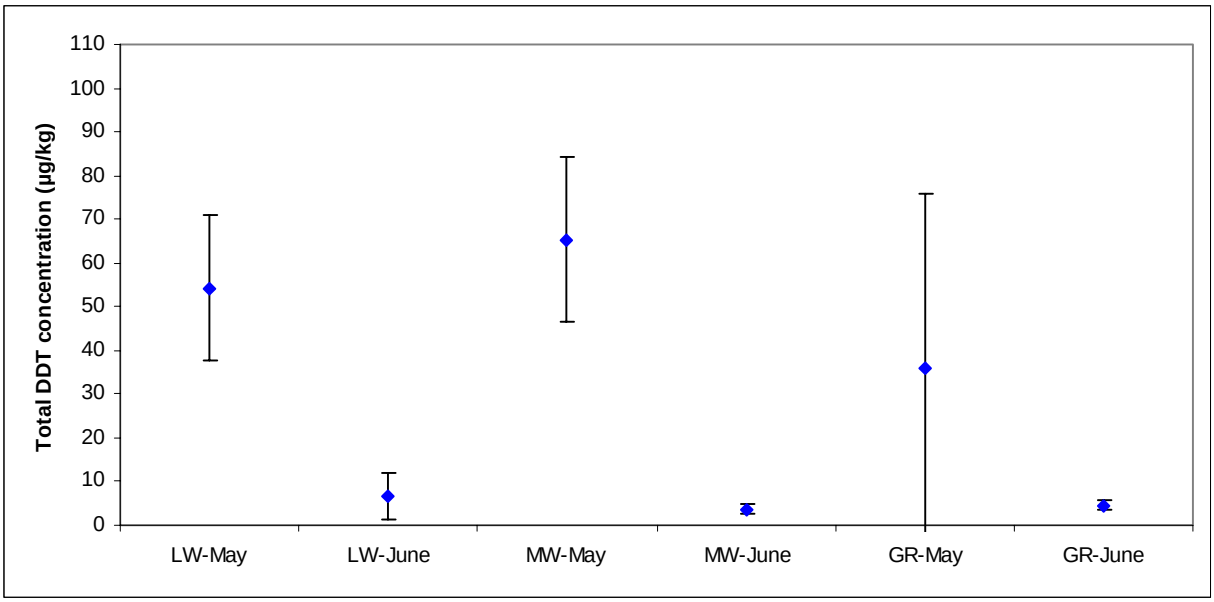

Figure 4-2. Mean total DDT concentrations and standard deviations for wild juvenile chinook salmon whole-body composite samples

Twenty-two pesticides other than DDT, DDE and DDD were analyzed in whole body tissue samples (Table 4-3). The raw data for pesticides are presented in Appendix D. Four pesticides were not detected in any tissue samples (cis-nonachlor, delta-BHC, mirex, and toxaphene). The remaining 18 pesticides were detected in at least one tissue sample. Table 4-3 summarizes the range of detected concentrations and frequency of detection for each compound. Detected concentrations of these pesticides ranged from 0.086 to 40 µg/kg ww.

Table 4-3. Summary of detected organochlorine pesticides (other than DDTs) in juvenile chinook salmon whole-body composite samples

Parameter	Detection Frequency	Detection Limits [a]	Detected Concentrations (µg/kg ww)	
			Minimum	Maximum
Aldrin	2/28	0.20 – 1.9	0.61	0.99
alpha-BHC	1/28	0.16 – 2.3	0.77	0.77
alpha-chlordane	5/28	0.36 – 2.6	0.77	4.5
alpha-Endosulfan	9/28	0.13 – 3.5	0.21	1.5
beta-BHC	11/28	0.21 – 1.5	0.39	12
beta-Endosulfan	1/28	0.35 – 2.9	0.94	0.94
Dieldrin	9/28	0.11 – 7.1	0.52	5.7
Endosulfan sulfate	6/28	0.27 – 2.0	0.73	2.3
Endrin	10/28	0.099 – 6.3	0.17	6.5
Endrin aldehyde	8/28	0.17 – 3.9	0.44	9.7
Endrin ketone	2/28	0.29 – 3.9	0.58	0.80

Parameter	Detection Frequency	Detection Limits [a]	Detected Concentrations (µg/kg ww)	
			Minimum	Maximum
gamma-BHC	5/28	0.28 – 2.5	0.34	3.0
gamma-chlordane	12/28	0.14 – 2.0	0.32	40
Heptachlor	7/28	0.45 – 3.2	0.76	2.5
Heptachlor epoxide	18/28	0.15 – 7.4	0.31	8.2
Methoxychlor	1/28	0.27 – 2.0	0.44	0.44
Oxychlordane	7/28	0.077 – 1.0	0.086	1.5
Trans-nonachlor	11/28	0.11 – 15	0.62	3.2

[a] Detection limit range for non-detects only

4.1.3 TBT

TBT was detected in all of the whole-body composite samples of wild fish collected from LW and MW stations in May, but only in some of the whole-body composite samples of hatchery fish collected from LW and MW stations in June (Table 4-4). TBT was not detected in any wild fish collected in June or in the fish collected from the Soos Creek Hatchery or the Green River. In May, TBT was detected in all waterway whole-body composite samples. In June, TBT was detected in 3 of 6 waterway whole-body composite samples. TBT concentrations in individual whole-body composite samples ranged from <1.1 to 14 µg/kg ww. Mean TBT concentrations per location ranged from <1.1 to 12 µg/kg ww in wild fish collected in May and June, and from <1.5 to 2.1 µg/kg ww in hatchery fish collected in June.

Table 4-4. TBT concentrations (µg TBT/kg ww) in juvenile chinook salmon whole-body composite samples

Location	Composite	Wild				Hatchery			
		May	Qual	June	Qual	May	Qual	June	Qual
Lower Waterway (LW)	1	13	J	1.5	UJ	nc		1.5	UJ
	2	8.8	J	1.5	UJ	nc		3.4	J
	3	14	J	1.5	UJ	nc		1.5	UJ
Mean ± SD		12 ± 2.8		1.5	UJ			2.1 ± 1.1	
Middle Waterway (MW)	1	7.2	J	1.5	UJ	nc		1.9	J
	2	10	J	1.5	UJ	nc		1.5	UJ
	3	7.1	J	1.5	UJ	nc		1.8	J
Mean ± SD		8.1 ± 2.0		1.5	UJ			1.7 ± 0.21	
Green River [a] (GR)	1	1.5	UJ	1.5	UJ	nc		1.5	UJ
	2	1.1	UJ	1.5	UJ	nc		1.5	UJ
	3	1.5	UJ	1.5	UJ	nc		1.5	UJ
Mean		1.1	UJ	1.5	UJ			1.5	UJ
Soos Creek (SC)	1	nc		nc		1.5	UJ	nc	

[a] Collected at RM 13 in May and RM 18 in June

SD – standard deviation

J – Estimated value

U –The compound was analyzed for, but was not detected at or above the stated detection limit

nc – not collected

4.1.4 Lipids and percent solids

Percent lipid and percent total solids in whole-body composite samples are presented in Tables 4-5 and 4-6, respectively. Percent lipid in individual whole-body composite samples ranged from 0.55 to 2.8%. Mean percent lipid per location ranged from 0.88 to 2.3% in wild fish collected in May and June, and from 1.1 to 1.4% in hatchery fish collected in June. Percent solids in individual whole-body composite samples ranged from 19.6 to 23.8%. Mean percent solids per location ranged from 20.1 to 21.6% in wild fish collected in May and June, and from 20.3 to 20.7% in hatchery fish collected in June.

Table 4-5 Percent lipid in juvenile chinook salmon whole-body composite samples

Location	Composite	Wild		Hatchery	
		May	June	May	June
Lower Waterway (LW)	1	0.55	1.5	nc	1.4
	2	1.0	1.8	nc	1.2
	3	1.1	1.7	nc	1.7
Mean ± SD		0.88 ± 0.29	1.7±0.15		1.4 ± 0.25
Middle Waterway (MW)	1	0.70 [a]	2.8	nc	1.2
	2	0.98	1.4	nc	1.4
	3	1.3	2.7	nc	1.5
Mean ± SD		0.99 ± 0.3	2.3 ± 0.78		1.4 ± 0.15
Green River[b] (GR)	1	1.3	1.6	nc	1.1
	2	1.3	1.8	nc	1.0
	3	0.85	2.1	nc	1.3
Mean ± SD		1.2 ± 0.26	1.8 ± 0.25		1.1 ± 0.15
Soos Creek (SC)	1	nc	nc	3.5 [a]	nc

[a] Value represents the average of laboratory triplicate results

[b] Collected at RM 13 in May and RM 18 in June

SD – standard deviation

nc – not collected

Table 4-6. Percent total solids in juvenile chinook salmon whole-body composite samples

Location	Composite	Wild		Hatchery	
		May	June	May	June
Lower Waterway (LW)	1	20.3	21.4 [a]	nc	20.5 [a]
	2	19.9	21.2	nc	19.8
	3	21.3	20.6	nc	20.7
Mean ± SD		20.5 ± 0.72	21.1 ± 0.42		20.3 ± 0.47
Middle Waterway (MW)	1	20.3	22.2	nc	20.7
	2	20.2	20.7	nc	20.7
	3	19.9	21.9	nc	20.8
Mean ± SD		20.1±0.79	21.6 ± 0.79		20.7 ± 0.058
Green River[b] (GR)	1	23.8	20.9	nc	20.9
	2	20	20.7	nc	20.3
	3	19.6	20.8	nc	20.3
Mean ± SD		21.1 ± 2.3	20.8 ± 0.10		20.5 ± 0.35
Soos Creek (SC)	1	nc	nc	21.8	nc

[a] Value represents the average of laboratory triplicate results

[b] Collected at RM 13 in May and RM 18 in June

SD – standard deviation

nc – not collected

4.1.5 Data validation results

Data validation of the whole-body tissue data found that, in general, project DQIs were met. None of the data were rejected.

However, additional data qualifiers were required for some of the pesticide and PCB results as well as all of the TBT results. All the TBT results were qualified as estimated because of low surrogate recoveries in laboratory control and matrix spike samples. The surrogate recoveries ranged from 16 to 27%. The project DQI for surrogate recoveries was 50 to150%.

For the pesticides and PCBs, the primary reason for additional qualifiers was high relative percent differences (RPDs) reported for pesticides and PCBs when the results of the two chromatographic columns were compared. The method dual column RPD criterion of 40% was exceeded, which necessitated qualifying the associated concentrations as estimates. In addition, two method blanks were contaminated with methoxychlor. The only detected concentration of methoxychlor (sample LDW-SC-H-WF-Comp1) was considered to be not detected at the reported concentration because of the reported blank contamination.

It was noted that selected organochlorine pesticides and PCBs congeners were potentially co-eluting in the samples. The presence of these chemicals together in a sample results in some degree of uncertainty for organochlorine pesticides that are present in low concentrations. In the LDW dataset, the co-elution of these components

may have resulted in an overestimation of concentrations reported for some of the organochlorine pesticides and possibly the PCBs. Currently, there are no alternative methods for the analysis of organochlorine pesticides that can be used to eliminate interferences attributable to the presence of PCBs. Because of the co-elution issues discussed above, additional procedures were not conducted at this time for the following reasons:

- the actual concentrations of organochlorine pesticides, if present, may be at most equal to, or more likely less than their reported concentrations;[4] thus, these data will provide realistic or conservative risk estimates in the Phase 2 risk assessments
- the reported concentrations of organochlorine pesticides (if present) in juvenile chinook salmon tissue are low relative to concentrations associated with adverse effects to juvenile salmon or those receptors consuming salmon; thus, these pesticides are unlikely to be risk drivers at the site

The co-elution of selected organochlorine pesticides and PCB congeners may have positively biased the concentrations of organochlorine pesticides reported as detected above the applicable method reporting limit in some samples. For this reason, the specific organochlorine pesticide results reported as detected were qualified as estimated (J). The potential overestimation of some of the organochlorine pesticide concentrations will be discussed in the risk assessments if risks are identified based on these samples.

4.2. STOMACH CONTENT RESULTS

As described in Section 2.2, stomach contents from 74 individual hatchery fish collected from the lower LDW were combined to form a single composite sample for chemical analysis. Prior to compositing, these stomach contents were also visually inspected. Contents ranged from primarily aquatic invertebrate species in some fish to primarily terrestrial insects in other fish, and many of the contents were unrecognizable. Amphipods and worms, as well as insect body parts (wings, legs, heads), were identified in approximately 80% of the stomach content samples.

4.2.1 Analytical results for stomach content sample

Analytical results for the one composite stomach content sample collected in the lower LDW are presented in Table 4-7. All metals were detected, at concentrations ranging from 0.040 mg/kg ww for silver to 23.5 mg/kg ww for zinc. The total non-alkylated PAH concentration in the composite stomach content sample was 1,280 µg/kg ww. Of

[4] When two compounds coelute, the signal resulting from the presence of both compounds is quantified as one compound, which results in an overestimation of the concentration of the quantified compound. For example, a chromatographic peak identified as DDT that results from the presence of both DDT and a PCB congener will be larger than the peak associated with DDT alone, and therefore, a higher DDT concentration will be reported due to the presence of the coeluting PCB congener.

this total, 520 µg/kg ww was low-molecular-weight PAHs (LPAHs) and 760 µg/kg ww was high-molecular-weight PAHs (HPAHs). The total alkylated PAH concentration was 1,640 µg/kg ww.

Table 4-7. Analytical results for the hatchery juvenile chinook salmon composite stomach content sample collected from the lower LDW

Analyte	Unit (ww)	Concentration	Qual	Analyte	Unit (ww)	Concentration	Qual
Metals				**Total solids**	%	20.8	
Arsenic	mg/kg	0.81[a]		**Alkylated PAHs**			
Cadmium	mg/kg	0.095[a]		1-Methylnaphthalene	µg/kg	19	
Chromium	mg/kg	0.4[a]		2-Methylnaphthalene	µg/kg	26	
Copper	mg/kg	8.7[a]		C2-Naphthalenes	µg/kg	71	
Lead	mg/kg	0.55[a]		C3-Naphthalenes	µg/kg	140	
Silver	mg/kg	0.040[a]	J	C4-Naphthalenes	µg/kg	146	
Zinc	mg/kg	23.5[a]		C1-Fluorenes	µg/kg	59	J
LPAHs				C2-Fluorenes	µg/kg	120	J
Naphthalene	µg/kg	21		C3-Fluorenes	µg/kg	180	J
Acenaphthylene	µg/kg	2.7		C1-Dibenzothiophenes	µg/kg	110	
Acenaphthene	µg/kg	38		C2-Dibenzothiophenes	µg/kg	78	
Fluorene	µg/kg	55	J	C3-Dibenzothiophenes	µg/kg	84	
Phenanthrene	µg/kg	380	J	C1-Phenanthrenes/ Anthracenes	µg/kg	160	J
Anthracene	µg/kg	21		C2-Phenanthrenes/ Anthracenes	µg/kg	140	J
Total LPAHs[b]	**µg/kg**	**520**		C3-Phenanthrenes/ Anthracenes	µg/kg	110	J
HPAHs				C4-Phenanthrenes/ Anthracenes	µg/kg	58	J
Fluoranthene	µg/kg	350	J	C1-Fluoranthenes/ Pyrenes	µg/kg	91	
Pyrene	µg/kg	240	J	C1-Chrysenes	µg/kg	28	J
Benzo(a)anthracene	µg/kg	32	J	C2-Chrysenes	µg/kg	18	J
Chrysene	µg/kg	62	J	C3-Chrysenes	µg/kg	4.0	UJ
Benzo(b)fluoranthene	µg/kg	22	J	C4-Chrysenes	µg/kg	4.0	UJ
Benzo(k)fluoranthene	µg/kg	28	J	**Total alkylated PAHs[e]**	**µg/kg**	**1,640**	
Benzo(a)pyrene	µg/kg	10		**Other PAHs**			
Indeno(1,2,3-cd)pyrene	µg/kg	8.4		Benzo(e)pyrene	µg/kg	19	
Dibenzo(a,h)anthracene	µg/kg	0.90	U	Dibenzothiophene	µg/kg	26	
Benzo(g,h,i)perylene	µg/kg	6.5		Perylene	µg/kg	2.7	
Total HPAHs[c]	**µg/kg**	**760**		Biphenyl	µg/kg	12	
Total nonalkylated PAHs[d]	**µg/kg**	**1,280**		Dibenzofuran	µg/kg	40	

[a] The results are the average of two laboratory duplicates

[b] Total LPAHs is the sum of detected concentrations for naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene

[c] Total HPAHs is the sum of detected concentrations for fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3,-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene

[d] Total nonalkylated PAHs is the sum of total LPAHs and total HPAHs

[e] Total alkylated PAHs is the sum of detected concentrations for 1-methylnapthalene, 2-methylnapthalene, C2-naphthalenes, C3-naphthalenes, C4-naphthalenes, C1-fluorenes, C2-fluorenes, C3-fluorenes, C1-dibenzothiophenes, C2-dibenzothiophenes, C3-dibenzothiophenes, C1-phenanthrenes/anthracenes, C2-phenanthrenes/anthracenes, C3-phenanthrenes/anthracenes, C4-phenanthrenes/anthracenes, C1-fluoranthenes/pyrenes, C1-chrysenes, C2-chrysenes, C3-chrysenes, and C4-chrysenes

J – Estimated value

U – The compound was analyzed for, but was not detected at or above the stated detection limit

ww – wet weight

Note: sums are calculated according to the significant figure rules described in Appendix F

4.2.2 Data validation results

The review of the results for the composite stomach content sample resulted in additional data qualifiers for the PAH results because of two issues. First, high matrix spike (MS) recoveries were reported for six PAH compounds. The MS recoveries for these compounds ranged from 146 to 749% compared to the project DQI goal of 40 to 130%. The six compounds with elevated MS recoveries were all detected at relatively high concentrations in the sample (i.e., the six highest concentrations in the sample). Therefore, the elevated MS recoveries may reflect sample heterogeneity with respect to the concentrations of these compounds. Elevated recoveries were not reported for surrogate compounds or SRMs, suggesting that there was no systematic bias in the analysis. Therefore, the reported concentrations of these compounds and their associated alkylated homologs in the composite stomach content sample were qualified as estimated. In addition, standard reference material (SRM) results for six of the eight PAH compounds present in the SRM were below the minimum DQI goal with recoveries ranging from 23.9 to 34.7% compared to the DQI goal of 40 to 130%. As a result, concentrations of these individual PAHs and their associated alkylated homologs were qualified as estimated.

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