EAST WATERWAY OPERABLE UNIT
SUPPLEMENTAL REMEDIAL INVESTIGATION/ FEASIBILITY STUDY
FINAL DATA REPORT
JUVENILE CHINOOK SALMON TISSUE COLLECTION

For submittal to:

The US Environmental Protection Agency
Region 10
Seattle, WA

May 2010

Prepared by:

Wind Ward environmental LLC

200 West Mercer Street • Suite 401
Seattle, Washington • 98119

Table of Contents

List of Tables

List of Maps

Acronyms

Acronym	Definition
ARI	Analytical Resources, Inc.
ACG	analytical concentration goal
BEHP	bis(2-ethylhexyl) phthalate
BHC	benzene hexachloride
CAS	Columbia Analytical Services, Inc.
CFR	Code of Federal Regulations
COI	chemical of interest
CVAA	cold vapor atomic absorption
DCM	dichloromethane
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
EPA	US Environmental Protection Agency
ERA	ecological risk assessment
EW	East Waterway
GC/ECD	gas chromatography/electron capture detector
GC/MS	gas chromatography/mass spectrometry
GFAAS	graphite furnace atomic absorption spectrophotometry
GI	gastrointestinal
ICP/AES	inductively couple/plasma atomic emission spectrometry
ICP/MS	inductively coupled/plasma mass spectrometry
ICSA	interference check sample A
ID	identification
J-qualifier	estimated concentration
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
MS	matrix spike
MSD	matrix spike duplicate
MDL	method detection limit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PSEP	Puget Sound Estuary Program
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan

RL	reporting limit
ROC	receptor of concern
SDG	sample delivery group
SOP	standard operating procedure
SVOC	semivolatile organic compound
TBT	tributyltin
U-qualifier	not detected at given concentration
WDFW	Washington State Department of Fish and Wildlife
Windward	Windward Environmental LLC
ww	wet weight
Y-qualifier	elevated reporting limit

1 Introduction

This data report presents the results of chemical analyses of juvenile Chinook salmon (*Oncorhynchus tshawytscha)* tissue collected on June 10 and 11, 2009, as part of the supplemental remedial investigation for the East Waterway (EW). Sampling and analyses were conducted in accordance with the *Quality Assurance Project Plan: Juvenile Chinook Salmon Collection and Chemical Analysis* (Windward 2009), hereafter referred to as the Juvenile Chinook Salmon Quality Assurance Project Plan (QAPP). Field catch results and the results of the chemical analyses of juvenile Chinook salmon samples are provided in this report. Juvenile Chinook salmon whole-body tissue samples were analyzed for total metals, butyltins, polycyclic aromatic hydrocarbons (PAHs), phthalates, semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs) as Aroclors, pesticides, lipids, and total solids. The stomach contents sample was analyzed for total metals, PAHs, and total solids.

The primary objectives for collecting the tissue data under the Juvenile Chinook Salmon QAPP (Windward 2009) were to:

- Characterize the chemical exposure for juvenile Chinook salmon, an ecological receptor of concern (ROC) in the ecological risk assessment (ERA), through all exposure routes by means of tissue-residue exposure analysis.[1]
- Characterize chemical exposure for juvenile Chinook salmon[2] and wildlife ROCs (birds and mammals that may consume juvenile salmon as prey) through the food chain by means of dietary exposure analysis.

This report is organized into sections that present collection and processing methods, analytical methods, chemical analysis results, and references. The text is supported by the following appendices:

- Appendix A – Chinook Compositing Memorandum
- Appendix B – Data Management
- Appendix C – Data Validation Report
- Appendix D – Laboratory Report Forms

[1] A tissue-residue approach is not appropriate for estimating risk to juvenile Chinook salmon from PAHs or metals (other than tributyltin [TBT], mercury, or selenium) because fish actively regulate these chemicals of interest (COIs).

[2] For metals (other than TBT, mercury, or selenium) an exposure media (i.e., diet or water) approach is preferred. Stomach contents chemistry data will be used to assess dietary risk to juvenile Chinook salmon. Thus, stomach contents were only analyzed for PAHs and metals (other than TBT, mercury, or selenium).

- Appendix E – Field Collection Forms and Field Notes
- Appendix F – Chain-of-Custody and Compositing Forms

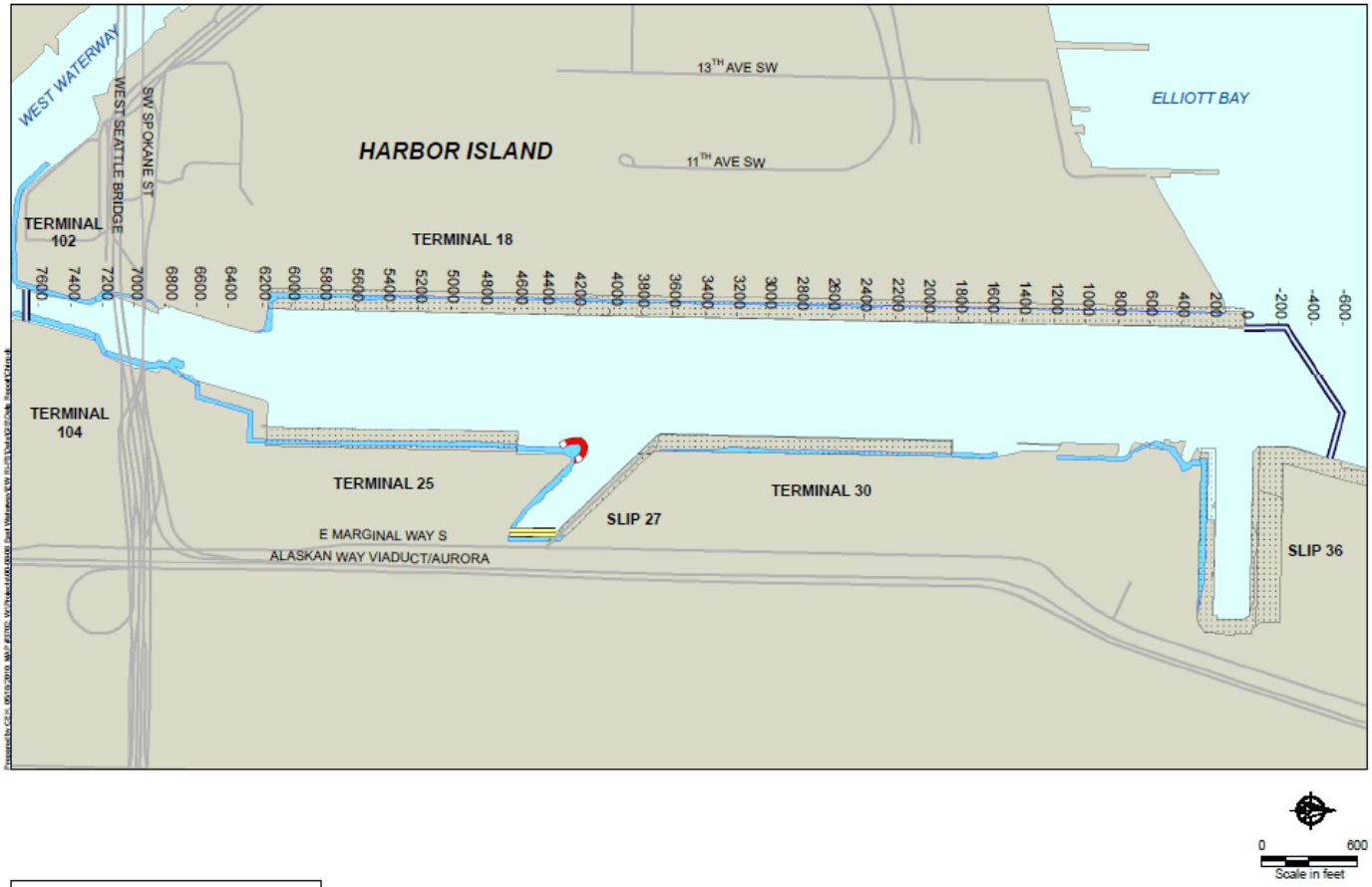
2 Juvenile Chinook Salmon Collection and Sample Processing Methods

This section summarizes the methods used to collect and process juvenile Chinook salmon. The field procedures used to collect these samples are described in detail in the Juvenile Chinook Salmon QAPP (Windward 2009). Section 2.1 presents the juvenile Chinook salmon sampling methods, Section 2.2 presents sample identification, compositing and processing methods; Section 2.3 describes field deviations from the QAPP.

2.1 JUVENILE CHINOOK SALMON COLLECTION

This section discusses the species targeted for collection, sampling methods, and catch results. Sampling locations are presented on Map 2-1. Juvenile Chinook salmon sampling was conducted on June 10 and 11, 2009.

In addition, it should be noted that juvenile chum salmon sampling was conducted on April 28, 2009. However, these samples were not used because sufficient juvenile Chinook salmon samples were collected during the June sampling event.



Map 2-1. Juvenile Chinook salmon sampling location

2.1.1 Targeted species

To meet the study objectives as presented in Section 2.2 of the Juvenile Chinook Salmon QAPP (Windward 2009), juvenile Chinook salmon were collected from the EW to estimate their chemical exposure during outmigration through the EW. As discussed in the Juvenile Chinook Salmon QAPP (Windward 2009), the Washington State Department of Fish and Wildlife (WDFW) describes the status of the federally threatened species Green River (Duwamish) Chinook salmon as "healthy" (WDFW 2002). In previous EW sampling events, juvenile Chinook salmon were caught in seine nets from April through September, with peak numbers found in April through July (Shannon 2006). Juvenile Chinook salmon are generally regarded as the most estuarine-dependant salmonid, with residence time for wild juvenile Chinook salmon in the 5-mile-long Lower Duwamish Waterway immediately upstream of the EW ranging from 2 weeks to 2 months (Ruggerone and Volk 2004).

Because the numbers of both wild and hatchery juvenile Chinook in EW can be limited, juvenile chum salmon were collected in April. These fish were to be used as a surrogate for whole-body and/or dietary analyses if insufficient numbers of juvenile Chinook salmon or mass of stomach contents were not collected for analysis during the June sampling event. As discussed in the QAPP (Windward 2009), juvenile chum salmon are also highly dependent on estuaries, feed on similar organisms, and have similar habitat use as juvenile Chinook salmon. Chum salmon specimens (and stomach contents) were archived until after Chinook sampling was completed and it was known that sufficient juvenile Chinook salmon were retained. The archived chum salmon were disposed of after it was known that sufficient Chinook were collected during the June 2009 sampling event.

2.1.2 Collection methods

Sampling for juvenile chum salmon occurred in April 2009, and sampling for juvenile Chinook salmon was conducted in June 2009 to coincide with the peak outmigration of each species. Both sampling events took place using a beach seine from the mouth of Slip 27 (Map 2-1). As discussed in the Juvenile Chinook Salmon QAPP (Windward 2009), fishing during both the April and June events began at Slip 27; fishing was also to occur at Slip 36, at the discretion of the field coordinator, if it was determined that sampling at Slip 36 might yield better results. However, no sampling at Slip 36 was conducted because sufficient numbers of juvenile Chinook and chum salmon were collected from the mouth of Slip 27.

The targeted fish were collected using a standard beach seine. The beach seine measured 37 m long and 3 m deep, with 6-mm mesh in the wings and 5-mm mesh in the center bag. The seine was equipped with floats, to minimize snagging of the lead line on submerged pilings, riprap, and other debris, and 30-m ropes to haul the net to shore. The net was deployed at low tide, as close to slack water as possible. Prior to each

deployment, the area, time of day, and weather conditions were recorded. To avoid contamination, the beach seine was cleaned of all debris before being deployed. The net was generally deployed 30 m from shore and parallel to the beach using an outboard motor-powered boat and three or four crew members, unless modifications were deemed necessary by the field crew.

One or two crew members stood onshore holding the 30-m rope attached to one end of the net until the boat, operating in reverse, pulled the rope taut. Once the rope was taut, another crew member fed the net from the bow of the boat into the water as the boat operator slowly motored in reverse to lay out all the net parallel to shore. The rope on the opposite end of the net was then brought to shore on the boat, and the crew member who had been in the bow of the boat deploying the net went ashore with the rope end to assist with net retrieval. Teams of one or two crew members stood at each end of the net, approximately 40 m apart, pulling the net toward shore at a steady rate. When the net was approximately 10 m from shore, the two teams moved together until they were about 10 m apart and then finished hauling the net up onto the shore.

Table 2-1 summarizes the beach seines set during both the April and June sampling events, along with the counts of target species collected for each seine attempt.

Table 2-1. Beach seine sampling locations

Sampling Location by Date	Set Number	Time	No. of Target Species Collected			
			Chum	Chinook, Wild	Chinook, Hatchery	Total
April 28, 2009						
Slip 27	001	1155	54	0	0	54
	002	1237	47	0	0	47
Daily total			**101**	**0**	**0**	**101**
June 10, 2009						
Slip 27	001	1003	0	0	2	2
	002	1033	0	4	5	9
	003	1104	0	0	6	6
	004	1122	0	0	0	0
	005	1136	0	2	14	16
	006	1156	0	4	21	25
	007	1226	0	3	42	45
	008	1304	0	11	16	27
	009	1342	0	6	0	6
	010	1407	0	4	0	4
	011	1432	0	1	0	1
Daily total			**0**	**35**	**106**	**141**

Sampling Location by Date	Set Number	Time	No. of Target Species Collected			
			Chum	Chinook, Wild	Chinook, Hatchery	Total
June 11, 2009						
Slip 27	012	1046	0	0	0	0
	013	1110	0	1	0	1
	014	1130	0	4	0	4
	015	1150	0	0	0	0
	016	1204	0	0	0	0
	017	1228	0	3	0	3
	018	1246	0	4	0	4
	019	1309	0	6	0	6
	020	1337	0	1	0	1
	021	1355	0	3	0	3
	022	1412	0	2	0	2
Daily total			**0**	**24**	**0**	**24**
Overall Total			**101**	**59**	**106**	**266**

2.1.3 Field sample processing

Fish were processed using a live sampling technique to minimize the mortality of non-target species through species sorting and processing prioritization. Upon completion of an individual beach seine set, the catch was immediately emptied into a large plastic tub or returned directly to the water, whichever was judged to be less stressful to the non-target species fish. Field crew then sorted the catch by species and size into numerous smaller tubs. Target species were separated from non-target species and processed. Non-target species were identified to the lowest practical taxon, the numbers of fish captured were estimated, and the fish were returned immediately to the location of capture.

The targeted number of individual juvenile Chinook salmon captured in the beach seines was checked for clipped adipose fins or presence of a coded wire tags to determine whether the fish were wild[3] or hatchery-raised. Fish were sorted and placed in a 5-gal. bucket filled with ice. All fish were carefully inspected to ensure that the sampling equipment did not damage their skin or fins. All individual specimens from each beach seine set were placed in one large ziplock bag, with the date, sampling location, and set number recorded on the outside of the bag in indelible ink, and then placed in a cooler with ice. The iced fish were transported in coolers to Analytical

[3] Non-marked fish were considered to be wild, although a small percentage of hatchery fish are not clipped or tagged prior to release.

Resources, Inc. (ARI) for further processing of tissue samples and for stomach contents analysis.

The date, time, and location of each effort were recorded in the field notebook, the Stomach Contents Tally Form (see Section 2.2), and the Non--target Species Tally Form. Completed field forms are presented in Appendix E.

2.1.4 Catch results

A total of 165 juvenile Chinook salmon and 101 juvenile chum salmon were collected and retained for possible analysis. Target numbers specified in the QAPP (Windward 2009) were met or exceeded for juvenile Chinook salmon, and thus the juvenile chum salmon were not analyzed. Compositing information, including the specimen identification (ID), length, and weight for each target specimen included in a composite sample, are presented in Appendix A.

Non-target fish, crab, shrimp, and other invertebrate species captured in the EW were identified, recorded, and returned to the EW. A total of 11 fish species, including both target and non-target species and two types of invertebrates classified to the lowest taxonomic level practicable were collected from the EW. The names and numbers of each species captured, by sampling effort, are presented in Table 2-2.

Table 2-2. Numbers of individual specimens captured in the EW

Species	Scientific Name	Number of Specimens Captured		
		April 28, 2009	June 10 – 11, 2009	Total
Chinook salmon	*Oncorhynchus tshawytscha*	0	486	486[a]
Chum salmon	*Oncorhynchus keta*	223	627	850[b]
Coho salmon	*Oncorhynchus kisutch*	0	10	10
Comb jellies	*Ctenophora*	0	370[c]	370
Crescent gunnel	*Pholis laeta*	0	1	1
Dungeness crab	*Cancer magister*	1	0	1
Pacific herring	*Clupea pallasii marisalbi*	0	3	3
Pacific sand lance	*Ammodytes hexapterus*	1	3	4
Shiner surfperch	*Cymatogaster aggregata*	0	7	7
Striped perch	*Embiotoca lateralis*	0	3	3
Skate	*Rajidae* sp.	1	0	1
Smelt spp.	*Osmeridae* sp.	0	3	3
Threespine stickleback	*Gasterosteus aculeatus*	0	4	4
Unknown jellyfish sp.	unknown	0	68[c]	68
Total		**226**	**1,585**	**1,811**

[a] A total of 59 wild and 106 hatchery juvenile Chinook salmon were retained for processing during the June 2009 sampling event. All other juvenile Chinook salmon were released.

[b] A total of 101 juvenile chum salmon were archived after the April 2009 sampling event as a possible surrogate for juvenile Chinook salmon. All others were released.

[c] Number is approximate.

2.2 SAMPLE IDENTIFICATION, COMPOSITING, AND PROCESSING

This section presents methods used to process fish following collection in the field. Specimen and sample ID numbers are described for individual fish and also for the composite tissue samples. In addition, the compositing scheme is described.

2.2.1 Sample identification

For whole-body tissue samples, unique alphanumeric sample numbers were assigned to each individual fish specimen and each composite sample. The first four characters for all samples were "EW09" to identify that the sample was collected from the East Waterway project area in 2009. The next characters identified the sampling location: S27 for Slip 27. The next three characters, a three-digit number, identified the effort number (e.g., the second beach seine effort after the start of sampling was 002). The next three characters identified the individual species type as Chinook salmon (CHN) or chum salmon (CHU). Following these identifiers, the letters "H" or "W" were used to designate the specimen as a hatchery or wild fish. The final identifier was a sample number. For example, the sample ID EW09-S27-003-CHN-W-001 represented the first wild Chinook salmon sample collected from Slip 27 during the third East Waterway 2009 sampling effort. All relevant information for each individually wrapped and labeled target specimen, including sample ID, length, weight, external abnormalities, sample date, time, and location number, was recorded on the Stomach Contents Tally Form (Appendix E).

Once whole-body samples had been composited in the laboratory, a unique ID number was assigned to the composite. The compositing scheme was determined in consultation with EPA and specified which individual fish were included in each composite (see Section 2.1.4.3 and Appendix A) and the resulting composite ID. The whole-body composite samples included "EW09-CHN" followed by the letters "H" or "W" to designate hatchery or wild fish, the letters "comp" to indicate a composite sample, and a sequential two-digit number to identify the sample number. For example, the first Chinook hatchery salmon whole-body composite sample composed of fish collected from the East Waterway in 2009 was identified as EW09-CHN-H-comp01.

Stomach contents composite samples were identified with "EW09-CHN" followed by "SC" to indicate stomach contents, the letters "comp" to indicate a composite sample, and a two-digit sequential number. Stomach contents composite subsamples also included the letters "H" or "W" to identify the sample being composed of the stomach contents of hatchery or wild fish. The single final stomach contents composite sample, which included both hatchery and wild fish, was identified as EW09-CHN-SC-comp01.

2.2.2 Compositing scheme

All juvenile Chinook salmon tissue samples were chemically analyzed as composite samples, which were created by homogenizing individual specimens together. The compositing plan was developed in coordination with EPA, and the final plan was approved by EPA (Appendix A). The plan detailed the compositing strategy for the 59 wild and 106 hatchery fish. As specified in the Juvenile Chinook Salmon QAPP (Windward 2009), the compositing of whole-body fish did not mix wild and hatchery fish. The compositing strategy for stomach contents and whole-body fish is described below.

- **Stomach contents samples –** Stomach contents samples were composited as they were collected, with two composite samples created from the wild fish (2.4 g) and two other composite samples created from the hatchery fish (4.6 g). All four of these composites were combined into a single stomach contents composite sample with a mass of 6.605 g. The stomach contents composite samples from the wild and hatchery fish were combined into a single composite sample in order to have sufficient sample mass for PAHs and metals analyses. Total solids were determined during the freeze-drying process for metals analysis.
- **Wild Chinook salmon whole-body samples –** The 59 wild Chinook salmon whole-body samples were sorted to create three composite samples. Composite 1 contained the four yearling fish that were collected. These fish were substantially bigger than all the other fish. Yearling Chinook salmon are older and larger than sub-yearling fish. They are capable of feeding over a large area, including both marine and freshwater regimes. The sub-yearling wild Chinook salmon were sorted to create two composites.
- **Hatchery Chinook salmon whole-body samples –** The 105 hatchery Chinook salmon were sorted to create three composite samples. No yearling fish were identified as hatchery-released fish.

Details regarding the composite samples that were chemically analyzed are presented in Table 2-3.

Table 2-3. Summary of Chinook salmon composite samples

Composite Type	Composite ID	No. of Specimens/ Composite	Total Composite Mass (g)	Fish Length (mm)		Fish Weight (g ww)	
				Range	Mean	Range	Mean
Stomach Contents							
Hatchery and wild combined	EW09-CHN-SC-comp01	165	6.605	60–130	75	2.40–19.50	4.49

Composite Type	Composite ID	No. of Specimens/ Composite	Total Composite Mass (g)	Fish Length (mm)		Fish Weight (g ww)	
				Range	Mean	Range	Mean
Whole-Body							
Wild (yearlings)	EW09-CHN-W-comp01	4	66.33	110–130	121	13.86–19.50	16.58
Wild	EW09-CHN-W-comp02	28	112.57	64–90	73	2.48–6.64	4.02
	EW09-CHN-W-comp03	27	107.20	62–83	73	2.53–6.43	3.97
Hatchery	EW09-CHN-H-comp01	36	154.46	61–85	74	2.40–7.14	4.29
	EW09-CHN-H-comp02	35	150.43	60–87	74	2.55–6.60	4.30
	EW09-CHN-H-comp03	34	142.85	62–84	73	2.51–6.57	4.20

ID – identification

ww – wet weight

2.2.3 Laboratory sample processing

Prior to freezing the fish and stomach contents for storage, the stomachs were surgically removed at ARI by Windward Environmental LLC (Windward) staff. During the processing, hatchery and wild specimens from each beach seine set were kept separate from one another and processed one at a time to ensure that individual specimens were tracked properly. Each individual specimen of the target species was weighed using an analytical scale accurate to 0.5 g wet weight (ww). Fish were cut from the anal vent to the head and the entire gastrointestinal (GI) tract was removed.

Fish were checked for the presence of coded wire tags, but none were found during processing. Gut contents were squeezed out of the stomachs by hand or, if this was infeasible, the gut was cut open with scissors and gut contents were scraped out. Fullness of the gut and distinguishable prey contents were noted. Gut contents were weighed to the nearest 0.01 g and composited using a sufficient number of randomly selected fish to generate a suitable composite sample. A composite was considered complete when the accumulated gut contents weighed at least 18 g and included the gut contents from at least 20 fish. Composite samples were collected in pre-cleaned, tared, 4-oz jars, and identification labels were attached to indicate the sample number and date sampled. After the removal of gut contents, the GI tract was returned to the fish and the fish were reweighed. The fish were then placed individually in pre-cleaned glass jars, along with all liquid from the fish, and labeled with the label taped to the outside of the jar. Samples were stored frozen at the laboratory.

The final homogenization and compositing scheme for the juvenile Chinook salmon tissue samples was determined in discussions between the East Waterway Group and EPA. Samples were kept frozen at ARI until the fish compositing scheme was approved by EPA. After the final compositing scheme was approved by EPA, all specimens were thawed and homogenized using a blender, chopper, and/or meat grinder. Tissue dissection and homogenization was performed by qualified laboratory technicians following ARI's standard operating procedures (SOPs) under Windward's oversight. All equipment used for fish processing was completely disassembled and cleaned prior

to initial use and after each composite sample, in accordance with the laboratory's SOP, to ensure that no cross-contamination occurred.

Individual Chinook salmon specimens were homogenized into whole-body tissue composite samples at ARI; the stomach contents were initially separated into four composite samples by Windward staff at ARI. These stomach contents composite sub-samples were further composited into a single stomach contents composite sample at Columbia Analytical Services, Inc., (CAS). Compositing was performed according to the compositing scheme presented in the Chinook compositing memorandum (Appendix A). A list of individual specimens used in each whole-body tissue composite sample is presented in Appendix A and discussed further in Section 2.2.2.

2.3 FIELD DEVIATIONS FROM THE QAPP

Field deviations from the Juvenile Chinook Salmon QAPP (Windward 2009) included minor modifications to collection and/or processing methods. These field deviations did not affect the data quality and are discussed in detail below.

- Length and weight data were recorded on the Stomach Contents Tally Form, rather than on the Target Species Tally Form. Target Species Tally Forms were not completed because of the redundancy in these forms (see Appendix E).
- A total of 165 juvenile Chinook salmon were collected during the June 2009 sampling effort. This was slightly more than the 160 juvenile Chinook salmon allowed under the WDFW scientific collection permit. There were no violations of the National Marine Fisheries Service permit, which specified the number of wild juvenile Chinook salmon that could be collected.
- Sample EW09-S27-006-CHN-H-008 could not be located at the laboratory at the time of sample compositing and was therefore not included in the composite sample EW09-CHN-H-comp03, as noted in the Chinook compositing memorandum (Appendix A).

3 Analytical Methods

The methods and procedures used to prepare and chemically analyze the tissue and stomach contents composite samples are described briefly in this section and in detail in the Juvenile Chinook Salmon Tissue QAPP (Windward 2009). This section also summarizes any laboratory deviations from the QAPP. Analytical testing adhered to the most recent EPA quality assurance/quality control (QA/QC) guidelines and analysis protocols (EPA 2002a; PSEP 1997).

3.1 FISH TISSUE AND STOMACH CONTENTS ANALYTICAL METHODS

Whole-body composite tissue composite samples were analyzed for total metals, total mercury, butyltins, SVOCs, PCBs as Aroclors, pesticides, lipids, and total solids. The

stomach contents composite sample was analyzed for PAHs, including alkylated PAHs, metals, and total solids.

The analytical methods followed by ARI and CAS adhered to the most recent EPA QA/QC guidelines and standard analysis protocols (EPA 2002b; PSEP 1997). All methods selected represent standard methods used for the analysis of these chemicals in tissue. The analytical methods used are identified in Table 3-1.

Table 3-1. Analytical methods for juvenile Chinook salmon whole-body tissue and stomach contents analyses

Parameter	Method	Reference	Laboratory	Maximum Sample Holding Time
PCBs as Aroclors	GC/ECD	EPA 8082	ARI	1 year to extract, 40 days to analyze
Organochlorine pesticides[a]	GC/ECD	EPA 8081B	ARI	1 year to extract, 40 days to analyze
SVOCs including PAHs[b]	GC/MS	EPA 8270D	ARI	1 year to extract, 40 days to analyze
PAHs and alkylated homologs	GC/MS-SIM	EPA 8270C-SIM	CAS	1 year to extract, 40 days to analyze
Mercury	CVAA	EPA 7471	ARI	60 days
Total metals[c]	ICP/MS, ICP/AES, and GFAAS	EPA 6020, 6010B, and 7740	ARI and CAS	6 months
Tributyltin, dibutyltin, monobutyltin (as ions)	GC/MS-SIM	Krone (1989)	ARI	1 year to extract, 40 days to analyze
Lipids	DCM: acetone extraction gravimetric	NOAA (1993)	ARI	1 year
Total solids	freeze-dried or oven-dried	PSEP (1997) or EPA 160.3	ARI and CAS	6 months

[a] Target pesticides included 4,4′-DDT, 4,4′-DDE, 4,4′-DDD, 2,4′-DDT, 2,4′-DDE, 2,4′-DDD, aldrin, alpha-BHC, beta-BHC, delta-BHC, gamma-BHC, oxychlordane, alpha- and gamma-chlordane, cis- and trans-nonachlor, dieldrin, endosulfan, endosulfan sulfate, endrin, heptachlor, heptachlor epoxide, methoxychlor, mirex, and toxaphene.

[b] Target PAHs included anthracene, pyrene, dibenzofuran, benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, benzo(b)fluoranthene, fluoranthene, benzo(k)fluoranthene, acenaphthylene, chrysene, benzo(a)pyrene, dibenz(a,h)anthracene, benzo(a)anthracene, acenaphthene, phenanthrene, fluorene, 1-methylnaphthalene, naphthalene, 2-methylnaphthalene.

[c] Target metals included arsenic, antimony, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc.

ARI – Analytical Resources, Inc.
BHC – benzene hexachloride
CAS – Columbia Analytical Services
CVAA – cold vapor atomic absorption
DCM – dichloromethane
DDD – dichlorodiphenyldichloroethane
GFAAS – graphite furnace atomic absorption spectrophotometry
ICP/AES – inductively couple/plasma atomic emission spectrometry
ICP/MS – inductively coupled/plasma mass spectrometry
NOAA – National Oceanic and Atmospheric Administration

DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
EPA – US Environmental Protection Agency
GC/ECD – gas chromatography/electron capture detector
GC/MS – gas chromatography/mass spectrometry
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PSEP – Puget Sound Estuary Program
SIM – select ion monitoring
SVOC – semivolatile organic carbon

3.2 LABORATORY DEVIATIONS FROM THE QAPP

The laboratories followed the methods and procedures described in the QAPP with the following exceptions:

- Insufficient sample mass was available to analyze all of the whole-body composite samples for all parameters. Specifically, butyltins could not be analyzed in sample EW09-CHN-W-comp01; and total solids could not be analyzed in samples EW09-CHN-W-comp01, EW09-CHN-W-comp02, and EW09-CHN-W-comp03.
- In consultation with the EPA QA office, total metals and total solids in the stomach contents composite sample were analyzed by CAS instead of ARI as specified in the QAPP (Windward 2009).
- Butyltins were analyzed using gas chromatography/mass spectrometry with selective ion monitoring using Krone et al (1989). The QAPP (Windward 2009) specified butyltin analysis using gas chromatography/flame photometric detection by Stallard et al. (1988) in error. The quality of the data was not affected by this deviation.

4 Results of Chemical Analyses

This section presents the results of the chemical analyses and data validation of the juvenile Chinook salmon whole-body and stomach contents composite samples. Laboratory report forms are presented in Appendix D. The approach used to average laboratory replicates and the methods used to calculate concentrations of total PCBs and PAHs are presented in Appendix B.

The QA 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, 2002b, 2004). EcoChem, Inc., conducted the data review and summary validation. The results of the data validation are summarized in Section 4.3 and presented in full in Appendix C.

4.1 WHOLE-BODY TISSUE AND STOMACH CONTENTS CHEMISTRY RESULTS

This section presents the analytical chemistry results for total metals, butyltins, PAHs, phthalates, other SVOCs, PCBs as Aroclors, pesticides, lipids, and total solids.

4.1.1 Metals

All metals were detected in the stomach contents composite sample, with the exception of selenium (Table 4-1). Concentrations of metals were generally higher in the stomach contents composite sample than in the whole-body tissue composite samples. Antimony, cadmium, lead, nickel, silver, and thallium were detected only in the stomach contents composite sample.

Table 4-1. Metals concentrations in juvenile Chinook salmon composite samples

Metals	Concentration by Sample Type(mg/kg ww)						
	Whole Body						Stomach Contents
	EW09-CHN-H-comp01	EW09-CHN-H-comp02	EW09-CHN-H-comp03	EW09-CHN-W-comp01	EW09-CHN-W-comp02	EW09-CHN-W-comp03	EW09-CHN-SC-comp01
Antimony	0.004 U	0.004 U	0.004 U	0.008 U	0.004 U	0.004 U	0.072
Arsenic	0.552	0.504	0.500	0.203	0.463	0.424	5.18
Cadmium	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.712
Chromium	0.2	0.2	0.2	0.3	0.4	0.3	2.32
Cobalt	0.10	0.12	0.11	0.06 U	0.09	0.08	0.563
Copper	1.00	1.46	1.01	2.02	1.08	1.29	25.2
Lead	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	2.93
Mercury	0.012 J	0.010 J	0.012 J	0.043 J	0.014 J	0.015 J	na
Molybdenum	0.2	0.2	0.2	0.2 J	0.2	0.2	0.60
Nickel	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.96
Selenium	0.37	0.35	0.37	0.36	0.35	0.35	1.73 U
Silver	0.06 U	0.06 U	0.06 U	0.06 U	0.07 U	0.06 U	0.139 J
Thallium	0.004 U	0.004 U	0.004 U	0.008 U	0.004 U	0.004 U	0.008 J
Vanadium	0.08	0.06 U	0.06	0.06 U	0.07 U	0.06 U	2.15
Zinc	38.2	39.2	37.8	46.2	36.7	35.4	122

na – not analyzed

U – not detected at given concentration

ww – wet weight

4.1.2 Butyltins

Butyltins were analyzed in five of the six juvenile Chinook salmon whole-body tissue composite samples. No butyltins were detected in juvenile Chinook salmon whole-body tissue composite samples, with RLs ranging from 6.7 to 11 µg/kg ww (Table 4-2). The stomach contents composite sample was not analyzed for butyltins.

Table 4-2. Butyltin concentrations in juvenile Chinook salmon composite samples

Butyltin	Concentration by Sample Type (µg/kg ww)						
	Whole Body						Stomach Contents
	EW09-CHN-H-comp01	EW09-CHN-H-comp02	EW09-CHN-H-comp03	EW09-CHN-W-comp01	EW09-CHN-W-comp02	EW09-CHN-W-comp03	EW09-CHN-SC-comp01
Monobutyltin as ion	7.9 U	7.8 U	7.3 U	na	7.0 U	7.5 U	na
Dibutyltin as ion	11 U	11 U	10 U	na	9.9 U	11 U	na
Tributyltin as ion	7.4 U	7.4 U	6.9 U	na	6.7 U	7.1 U	na

na – not analyzed

U – not detected at given concentration

ww – wet weight

4.1.3 Phthalates

Phthalates were analyzed in the six juvenile Chinook salmon whole-body tissue composite samples. Of the six phthalates analyzed, none were detected in the juvenile Chinook salmon whole-body tissue composite samples, with RLs ranging from 100 to 150 µg/kg ww (Table 4-3). The stomach contents composite sample was not analyzed for phthalates.

Table 4-3. Phthalate concentrations in juvenile Chinook salmon composite samples

Phthalate	Concentration by Sample Type (µg/kg ww)						
	Whole Body						Stomach Contents
	EW09-CHN-H-comp01	EW09-CHN-H-comp02	EW09-CHN-H-comp03	EW09-CHN-W-comp01	EW09-CHN-W-comp02	EW09-CHN-W-comp03	EW09-CHN-SC-comp01
Bis(2-ethylhexyl) phthalate	120 U	120 U	120 U	100 U	120 U	150 U	na
Butyl benzyl phthalate	120 U	120 U	120 U	100 U	120 U	150 U	na
Diethyl phthalate	120 U	120 U	120 U	100 U	120 U	150 U	na
Dimethyl phthalate	120 U	120 U	120 U	100 U	120 U	150 U	na
Di-n-butyl phthalate	120 U	120 U	120 U	100 U	120 U	150 U	na
Di-n-octyl phthalate	120 U	120 U	120 U	100 U	120 U	150 U	na

na – not analyzed

U – not detected at given concentration

ww – wet weight

4.1.4 PAHs

Table 4-4 presents the concentrations of PAHs in juvenile Chinook salmon whole-body tissue and stomach contents composite samples. Both the whole-body tissue and the stomach contents composite samples were analyzed for PAHs. No PAHs were detected in the whole-body tissue composite samples with reporting limits ranging from 100 to 150 µg/kg ww. All PAHs were detected in the stomach contents composite sample (Table 4-4). It should be noted that a more sensitive analytical technique was used for the analysis of the stomach contents composite sample with much lower reporting limits for the individual PAH compounds. The analyte lists for the two methods differed slightly which resulted in the analysis of benzo(e)pyrene and perylene in the stomach contents composite sample and not in the whole-body tissue composite samples. Similarly, 2-chlorobenzene was analyzed for in the whole-body tissue composite samples and not in the stomach contents composite sample.

Table 4-4. PAH concentrations in juvenile Chinook salmon composite samples

PAH	Concentration by Sample Type (µg/kg ww)						
	Whole Body						Stomach Contents
	EW09-CHN-H-comp01	EW09-CHN-H-comp02	EW09-CHN-H-comp03	EW09-CHN-W-comp01	EW09-CHN-W-comp02	EW09-CHN-W-comp03	EW09-CHN-SC-comp01
1-Methylnaphthalene	120 U	120 U	120 U	100 U	120 U	150 U	3.5 J
2-Chloronaphthalene	120 U	120 U	120 U	100 U	120 U	150 U	na
2-Methylnaphthalene	120 U	120 U	120 U	100 U	120 U	150 U	3.9 J
Acenaphthene	120 U	120 U	120 U	100 U	120 U	150 U	16 J
Acenaphthylene	120 U	120 U	120 U	100 U	120 U	150 U	1.2 J
Anthracene	120 U	120 U	120 U	100 U	120 U	150 U	15 J
Benzo(a)anthracene	120 U	120 U	120 U	100 U	120 U	150 U	33
Benzo(a)pyrene	120 U	120 UJ	120 UJ	100 U	120 U	150 U	9.8 J
Benzo(b)fluoranthene	120 U	120 UJ	120 UJ	100 U	120 U	150 U	39
Benzo(e)pyrene	na	na	na	na	na	na	19
Benzo(g,h,i)perylene	120 U	120 UJ	120 UJ	100 U	120 U	150 U	7.7 J
Benzo(k)fluoranthene	120 U	120 UJ	120 UJ	100 U	120 U	150 U	13 J
Total benzofluoranthenes	120 U	120 UJ	120 UJ	100 U	120 U	150 U	52 J
Chrysene	120 U	120 U	120 U	100 U	120 U	150 U	77
Dibenzo(a,h)anthracene	120 U	120 UJ	120 UJ	100 U	120 U	150 U	1.8 J
Dibenzofuran	120 U	120 U	120 U	100 U	120 U	150 U	12 J
Fluoranthene	120 U	120 U	120 U	100 U	120 U	150 U	230
Fluorene	120 U	120 U	120 U	100 U	120 U	150 U	18
Indeno(1,2,3-cd)pyrene	120 U	120 UJ	120 UJ	100 U	120 U	150 U	10 J
Naphthalene	120 U	120 U	120 U	100 U	120 U	150 U	6.9 J

PAH	Concentration by Sample Type (µg/kg ww)						
	Whole Body						Stomach Contents
	EW09-CHN-H-comp01	EW09-CHN-H-comp02	EW09-CHN-H-comp03	EW09-CHN-W-comp01	EW09-CHN-W-comp02	EW09-CHN-W-comp03	EW09-CHN-SC-comp01
Perylene	na	na	na	na	na	na	2.4 J
Phenanthrene	120 U	120 U	120 U	100 U	120 U	150 U	200
Pyrene	120 U	120 U	120 U	100 U	120 U	150 U	120
Total HPAHs	120 U	120 UJ	120 UJ	100 U	120 U	150 U	540 J
Total LPAHs	120 U	120 U	120 U	100 U	120 U	150 U	260 J
Total PAHs	120 U	120 UJ	120 UJ	100 U	120 U	150 U	800 J

HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
J – estimated concentration
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
na – not analyzed
PAH – polycyclic aromatic hydrocarbon
U – not detected at given concentration
ww – wet weight

The stomach contents composite sample was also analyzed for alkylated PAH. Seven groups of alkylated PAH were detected in the stomach contents composite sample. RLs for the non-detected alkylated PAHs were equal to 16 µg/kg ww. Detected alkylated PAH concentrations ranged from 17 to 86 µg/kg ww (Table 4-5).

Table 4-5. Alkylated PAH concentrations for the stomach contents sample

Alkylated PAH	Concentration (µg/kg ww)
	EW09-CHN-SC-comp01
C1-Chrysenes	27
C1-Dibenzothiophenes	16 U
C1-Fluoranthene/pyrene	62
C1-Fluorenes	16 U
C1-Phenanthrenes/anthracenes	86
C2-Chrysenes	27
C2-Dibenzothiophenes	16 U
C2-Fluorenes	16 U
C2-Naphthalenes	16 U
C2-Phenanthrenes/anthracenes	38
C3-Chrysenes	16 U
C3-Dibenzothiophenes	16 U
C3-Fluorenes	17
C3-Naphthalenes	16 U
C3-Phenanthrenes/anthracenes	31

Alkylated PAH	Concentration (µg/kg ww)
	EW09-CHN-SC-comp01
C4-Chrysenes	16 U
C4-Naphthalenes	16 U
C4-Phenanthrenes/anthracenes	16 U

PAH – polycyclic aromatic hydrocarbon

U – not detected at given concentration

ww – wet weight

4.1.5 Other SVOCs

SVOCs were analyzed in the six juvenile Chinook salmon whole-body tissue composite samples. No SVOCs were detected, with RLs that generally ranged from 100 to 750 µg/kg (ww) (Table 4-6). Two SVOCs (biphenyl and dibenzothiophene) were analyzed in the juvenile Chinook salmon stomach contents composite sample as a component of the PAH analysis but not in the whole-body tissue composite samples. Both of these SVOCs were detected in the stomach contents composite sample.

Table 4-6. SVOC concentrations in juvenile Chinook salmon composite samples

SVOC	Concentration by Sample Type (µg/kg ww)						
	Whole Body						Stomach Contents
	EW09-CHN-H-comp01	EW09-CHN-H-comp02	EW09-CHN-H-comp03	EW09-CHN-W-comp01	EW09-CHN-W-comp02	EW09-CHN-W-comp03	EW09-CHN-SC-comp01
1,2,4-Trichlorobenzene	120 U	120 U	120 U	100 U	120 U	150 U	na
1,2-Dichlorobenzene	120 U	120 U	120 U	100 U	120 U	150 U	na
1,3-Dichlorobenzene	120 U	120 U	120 U	100 U	120 U	150 U	na
1,4-Dichlorobenzene	120 U	120 U	120 U	100 U	120 U	150 U	na
2,4,5-Trichlorophenol	600 U	590 U	590 U	500 U	620 U	750 U	na
2,4,6-Trichlorophenol	600 U	590 U	590 U	500 U	620 U	750 U	na
2,4-Dichlorophenol	600 U	590 U	590 U	500 U	620 U	750 U	na
2,4-Dimethylphenol	120 U	120 U	120 U	100 U	120 U	150 U	na
2,4-Dinitrophenol	1,200 U	1,200 U	1,200 U	1,000 U	1,200 U	1,500 U	na
2,4-Dinitrotoluene	600 U	590 U	590 U	500 U	620 U	750 U	na
2,6-Dinitrotoluene	600 U	590 U	590 U	500 U	620 U	750 U	na
2-Chlorophenol	120 U	120 U	120 U	100 U	120 U	150 U	na
2-Methylphenol	120 U	120 U	120 U	100 U	120 U	150 U	na
2-Nitroaniline	600 U	590 U	590 U	500 U	620 U	750 U	na
2-Nitrophenol	600 U	590 U	590 U	500 U	620 U	750 U	na

SVOC	Concentration by Sample Type (µg/kg ww)						
	Whole Body						Stomach Contents
	EW09-CHN-H-comp01	EW09-CHN-H-comp02	EW09-CHN-H-comp03	EW09-CHN-W-comp01	EW09-CHN-W-comp02	EW09-CHN-W-comp03	EW09-CHN-SC-comp01
3,3′-Dichlorobenzidine	600 U	590 U	590 U	500 U	620 U	750 U	na
3-Nitroaniline	600 U	590 U	590 U	500 U	620 U	750 U	na
4,6-Dinitro-o-cresol	1,200 U	1,200 U	1,200 U	1,000 U	1,200 U	1,500 U	na
4-Bromophenyl phenyl ether	120 U	120 U	120 U	100 U	120 U	150 U	na
4-Chloro-3-methylphenol	600 U	590 U	590 U	500 U	620 U	750 U	na
4-Chloroaniline	600 U	590 U	590 U	500 U	620 U	750 U	na
4-Chlorophenyl phenyl ether	120 U	120 U	120 U	100 U	120 U	150 U	na
4-Methylphenol	120 U	120 U	120 U	100 U	120 U	150 U	na
4-Nitroaniline	600 U	590 U	590 U	500 U	620 U	750 U	na
4-Nitrophenol	600 U	590 U	590 U	500 U	620 U	750 U	na
Aniline	120 U	120 U	120 U	100 U	120 U	150 U	na
Benzoic acid	1,200 U	1,200 U	1,200 U	1,000 U	1,200 U	1,500 U	na
Benzyl alcohol	600 U	590 U	590 U	500 U	620 U	750 U	na
Biphenyl	na	na	na	na	na	na	3.1 J
Bis(2-chloroethoxy) methane	120 U	120 U	120 U	100 U	120 U	150 U	na
Bis(2-chloroethyl)ether	120 U	120 U	120 U	100 U	120 U	150 U	na
Bis(2-chloroisopropyl) ether	120 U	120 U	120 U	100 U	120 U	150 U	na
Carbazole	120 U	120 U	120 U	100 U	120 U	150 U	na
Dibenzothiophene	na	na	na	na	na	na	9.4 J
Hexachlorobenzene	1.9 U	1.8 U	1.8 U	2.0 U	2.0 U	2.0 U	na
Hexachlorobutadiene	1.9 U	1.8 U	1.8 U	2.0 U	2.0 U	2.0 U	na
Hexachloro-cyclopentadiene	600 UJ	590 UJ	590 UJ	500 U	620 UJ	750 UJ	na
Hexachloroethane	120 U	120 U	120 U	100 U	120 U	150 U	na
Isophorone	120 U	120 U	120 U	100 U	120 U	150 U	na
n-Nitroso-di-n-propylamine	600 U	590 U	590 U	500 U	620 U	750 U	na
n-Nitrosodimethylamine	600 U	590 U	590 U	500 U	620 U	750 U	na
n-Nitrosodiphenylamine	120 U	120 U	120 U	100 U	120 U	150 U	na
Nitrobenzene	120 U	120 U	120 U	100 U	120 U	150 U	na
Pentachlorophenol	600 U	590 U	590 U	500 U	620 U	750 U	na
Phenol	120 U	120 U	120 U	100 U	120 U	150 U	na

na – not analyzed
SVOC – semivolatile organic chemical
J – estimated concentration
U – not detected at given concentration

4.1.6 PCB Aroclors

Table 4-7 presents the results for PCB Aroclors for juvenile Chinook salmon whole-body tissue composite samples. Aroclors 1248, 1254, and 1260 were the only Aroclors detected in juvenile Chinook salmon whole-body tissue composite samples: Aroclor 1248 was detected in five of the six samples, Aroclor 1254 was detected in three of the six samples, and Aroclor 1260 was detected in all six samples. Total PCBs were calculated as the sum of the detected Aroclors. The concentrations of total PCBs in juvenile Chinook salmon whole-body tissue composite samples ranged from 7.4 to 72 µg/kg ww. PCBs were not analyzed in the stomach contents composite sample (Table 4-7).

Table 4-7. PCB Aroclor concentrations in juvenile Chinook salmon composite samples

PCB	Concentration by Sample Type (µg/kg ww)						
	Whole Body						Stomach Contents
	EW09-CHN-H-comp01	EW09-CHN-H-comp02	EW09-CHN-H-comp03	EW09-CHN-W-comp01	EW09-CHN-W-comp02	EW09-CHN-W-comp03	EW09-CHN-SC-comp01
Aroclor 1016	4.0 U	4.0 U	3.9 U	4.0 U	4.0 U	4.0 U	na
Aroclor 1221	4.0 U	4.0 U	3.9 U	4.0 U	4.0 U	4.0 U	na
Aroclor 1232	4.0 U	4.0 U	3.9 U	4.0 U	4.0 U	4.0 U	na
Aroclor 1242	4.0 U	4.0 U	3.9 U	4.0 U	4.0 U	4.0 U	na
Aroclor 1248	19	21	22	4.0 U	17	13	na
Aroclor 1254	21	21	22	12 U	40 U	20 U	na
Aroclor 1260	10	9.5	9.8	7.4	55	11	na
Aroclor 1262	4.0 U	4.0 U	3.9 U	4.0 U	4.0 U	4.0 U	na
Aroclor 1268	4.0 U	4.0 U	3.9 U	4.0 U	4.0 U	4.0 U	na
Total PCBs[a]	50	52	54	7.4	72	24	na

[a] The method for calculating total PCBs is presented in Appendix B.

na – not analyzed

PCB – polychlorinated biphenyl

U – not detected at given concentration

4.1.7 Pesticides

Pesticides were analyzed in the six juvenile Chinook salmon whole-body tissue composite samples (Table 4-8). No pesticides were detected in any of the juvenile Chinook salmon whole-body tissue composite samples, with reporting limits that generally ranged from 1.8 to 4.0 µg/kg ww. The stomach contents composite sample was not analyzed for pesticides.

Table 4-8. Pesticide concentrations in juvenile Chinook salmon composite samples

Pesticide	Concentration by Sample Type (µg/kg ww)						
	Whole Body						Stomach Contents
	EW09-CHN-H-comp01	EW09-CHN-H-comp02	EW09-CHN-H-comp03	EW09-CHN-W-comp01	EW09-CHN-W-comp02	EW09-CHN-W-comp03	EW09-CHN-SC-comp01
2,4′-DDD	3.8 U	3.6 U	3.6 U	4.0 U	4.0 U	4.0 U	na
2,4′-DDE	3.8 U	3.6 U	3.6 U	4.0 U	4.0 U	4.0 U	na
2,4′-DDT	3.8 U	3.6 U	3.6 U	4.0 U	4.0 U	4.0 U	na
4,4′-DDD	3.8 U	3.6 U	3.6 U	4.0 U	4.0 U	4.0 U	na
4,4′-DDE	3.8 U	3.6 U	3.6 U	4.0 U	4.0 U	4.0 U	na
4,4′-DDT	3.8 U	3.6 U	3.6 U	4.0 U	4.0 U	4.0 U	na
Total DDTs	3.8 U	3.6 U	3.6 U	4.0 U	4.0 U	4.0 U	na
Aldrin	1.9 U	1.8 U	1.8 U	2.0 U	2.0 U	2.0 U	na
Dieldrin	3.8 U	3.6 U	3.6 U	4.0 U	4.0 U	4.0 U	na
Total aldrin/dieldrin	3.8 U	3.6 U	3.6 U	4.0 U	4.0 U	4.0 U	na
alpha-BHC	1.9 U	1.8 U	1.8 U	2.0 U	2.0 U	2.0 U	na
beta-BHC	1.9 U	1.8 U	1.8 U	2.0 U	2.0 U	2.0 U	na
gamma-BHC	1.9 U	1.8 U	1.8 U	2.0 U	2.0 U	2.0 U	na
delta-BHC	1.9 U	3.3 U	1.8 U	2.0 U	2.0 U	2.0 U	na
alpha-Chlordane	1.9 U	1.8 U	1.8 U	2.0 U	2.0 U	2.0 U	na
gamma-Chlordane	1.9 U	1.8 U	1.8 U	2.0 U	2.0 U	2.0 U	na
Total chlordane	3.8 U	3.6 U	3.6 U	4.0 U	4.0 U	4.0 U	na
alpha-Endosulfan	1.9 U	1.8 U	1.8 U	2.0 U	2.0 U	2.0 U	na
beta-Endosulfan	3.8 U	3.6 U	3.6 U	4.0 U	4.0 U	4.0 U	na
Endosulfan sulfate	3.8 U	3.6 U	3.6 U	4.0 U	4.0 U	4.0 U	na
Endrin	3.8 U	3.6 U	3.6 U	4.0 U	4.0 U	4.0 U	na
Endrin aldehyde	3.8 U	3.6 U	3.6 U	4.0 U	4.0 U	4.0 U	na
Heptachlor	1.9 U	1.8 U	1.8 U	2.0 U	2.0 U	2.0 U	na
Heptachlor epoxide	1.9 U	1.8 U	1.8 U	2.0 U	2.0 U	2.0 U	na
Methoxychlor	19 U	18 U	18 U	20 U	20 U	20 U	na
Mirex	3.8 U	3.6 U	3.6 U	4.0 U	4.0 U	4.0 U	na
cis-Nonachlor	3.8 U	3.6 U	3.6 U	4.0 U	4.0 U	4.0 U	na
Oxychlordane	3.8 U	3.6 U	3.6 U	4.0 U	4.0 U	4.0 U	na
Toxaphene	750 U	720 U	710 U	800 U	790 U	800 U	na
trans-Nonachlor	3.8 U	3.6 U	3.6 U	4.0 U	4.0 U	4.0 U	na

BHC – benzene hexachloride
DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
na – not analyzed
U – not detected at given concentration
ww – wet weight

DDT – dichlorodiphenyltrichloroethane

4.1.8 Lipids and total solids

Table 4-9 presents the lipid and total solids percentages in juvenile Chinook salmon whole-body tissue composite samples. In whole-body tissue composite samples, lipids ranged from 0.758 to 1.78%, and total solids ranged from 19.96 to 20.28% in the hatchery juvenile Chinook salmon whole-body tissue composite samples. The wild juvenile Chinook salmon whole-body tissue composite samples had insufficient sample mass for the analysis of total solids. In the stomach contents composite sample, the total solids was 68.8%; lipids were not analyzed.

Table 4-9. Lipids and solids concentrations in juvenile Chinook salmon composite samples

	Whole-Body Tissue (% ww)						Stomach Contents (% ww)
Chemical	EW09-CHN-H-comp01	EW09-CHN-H-comp02	EW09-CHN-H-comp03	EW09-CHN-W-comp01	EW09-CHN-W-comp02	EW09-CHN-W-comp03	EW09-CHN-SC-comp01
Lipids	1.54	1.68	1.64	0.758	1.78	1.44	na
Total solids	19.96	20.14	20.28	na	na	na	68.8

na – not analyzed

ww – wet weight

4.2 COMPARISON OF NON-DETECTED RESULTS WITH ANALYTICAL CONCENTRATION GOALS

This section compares RLs and method detection limits (MDLs) for non-detected concentrations in tissue samples to site-specific analytical concentration goals (ACGs) for ecological receptors that were presented in Appendix D of the *East Waterway Operable Unit Supplemental Remedial Investigation/Feasibility Study, Quality Assurance Project Plan: Fish and Shellfish Tissue Collection and Chemical Analysis* (Windward 2008), hereafter referred to as the Fish and Shellfish Tissue Collection QAPP. The target detection limits for the analyses were also identified in the QAPP appendix and are presented in this section.

Actual MDLs and RLs may differ from the target detection limits as a result of sample dilutions because of analytical interferences (i.e., lipid content of the sample extracts). When sample extracts were diluted, RLs from an original, undiluted extract were reported for chemicals other than the target chemicals that required dilution, when available. The sample-specific RL was based on the lowest point of the calibration curve associated with each analysis, whereas the MDL was statistically derived following EPA methods (40 CFR 136). Detected concentrations between the MDL and RL were

reported by the laboratories and are flagged with a J-qualifier to indicate that the reported concentration is an estimate. Non-detect results were reported at the RL.

The RLs and MDLs for juvenile Chinook salmon samples are compared with risk-based ACGs for all chemicals in Table 4-10. Chemicals with RLs greater than ACGs included selenium, naphthalene, alpha-endosulfan, beta-endosulfan, endrin, endrin aldehyde, and methychlor. All of these chemicals also had one or more samples with MDLs that exceeded ACGs, with the exception of methoxychlor.

Table 4-10. Number of RLs and MDLs above the ecological receptor ACGs for juvenile Chinook salmon composite samples

Chemical	Unit	No. of Detects	Detected Conc.	No. of Non-Detects	RLs for Non-Detects	No. of RLs > ACGs	MDLs for Non-Detects	No. of MDLs > ACGs	Minimum Ecological ACG[a]	Target MDL	Target RL
Metals											
Selenium	mg/kg ww	6	0.35 – 0.37	1	1.73	1	0.21	1	0.33	0.028	0.04
PAHs											
Naphthalene	µg/kg ww	1	6.9 J	6	100 – 150	6	73 – 110	6	5.0	15	67
Pesticides											
alpha-Endosulfan[b]	µg/kg ww	0	nd	6	1.8 – 2.0	6	0.54 – 0.60	6	0.62	11	20
beta-Endosulfan[b]	µg/kg ww	0	nd	6	3.6 – 4.0	6	3.6 – 4.0	6	0.62	11	20
Endrin	µg/kg ww	0	nd	6	3.6 – 4.0	6	3.6 – 4.0	6	1.2	15	20
Endrin aldehyde[c]	µg/kg ww	0	nd	6	3.6 – 4.0	6	3.6 – 4.0	6	1.2	15	20
Methoxychlor	µg/kg ww	0	nd	6	18 – 20	6	9.0 – 10	0	15	63	10

[a] The lowest of the available ACGs for ecological receptors as presented in Appendix D of the Fish and Shellfish Tissue Collection QAPP (Windward 2008) was used to evaluate the RLs and MDLs.

[b] The ACG, target MDL, and target RL for endosulfan were used to evaluate this chemical.

[c] The ACG, target MDL, and target RL for endrin were used to evaluate this chemical.

ACG – analytical concentration goal
MDL – maximum detection limit
nd – not detected
PAH – polycyclic aromatic hydrocarbon
RL – reporting limit
ww – wet weight

The chemicals with RLs above ACGs were identified in Appendix D of the Fish and Shellfish Tissue Collection QAPP (Windward 2008) as having target MDLs and/or RLs above the lowest ecological ACGs, with the exception of selenium in the stomach contents composite sample. The selenium concentration in this sample was originally detected but was reclassified as a non-detect during data validation because of method blank contamination.

4.3 DATA VALIDATION RESULTS

Independent data validation of all results was performed by EcoChem in accordance with the QA/QC requirements and technical specifications of the methods and the national functional guidance for organic and inorganic data review (EPA 1999, 2004, 1994). EcoChem conducted full-level data validation on the majority of results. All sample results that were not selected for full validation underwent a summary validation. The percentage of samples submitted for full validation for each analysis is consistent with Juvenile Chinook Salmon QAPP (Windward 2009) requirements. Table 4-11 provides a summary of the number of samples in each sample delivery group (SDG) and the level of data validation.

Table 4-11. Data validation performed for each SDG

Laboratory	SDG	Validation Level	Number of Composite Samples	Analyses
ARI	QC62	full	6	SVOCs, PCBs, pesticides, butyltins, total metals including mercury, lipids, total solids
ARI	QF82	summary	1	SVOCs, total mercury
CAS	K1000029	full	1	PAHs including alkylated PAHs, total metals, total solids

ARI – Analytical Resources, Inc.
CAS – Columbia Analytical Services, Inc.
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SDG – sample delivery group
SVOC – semivolatile organic compound

The data validation involved a review of all QC summary forms, including initial calibration, continuing calibration verification, internal standard, surrogate, laboratory control sample (LCS), laboratory control sample duplicate (LCSD), matrix spike (MS), matrix spike duplicate (MSD), and interference check sample A (ICSA) summary forms. The majority of the data did not require qualification or were qualified with a J, indicating that the concentration was an estimated value. No results were rejected as a consequence of data validation. Based on the information reviewed, the overall data quality is considered acceptable for all uses, as qualified. Issues that resulted in the qualification of data are summarized below. Detailed information regarding every qualified sample is presented in Appendix C.

- Concentrations for various chemicals were qualified as estimated (J- or UJ-qualified) because internal standard, LCS/LCSD, ICSA, or contract-required detection limit standard recoveries were outside of control limits. Results qualified as estimated include the following: five results for hexachlorocyclopentadiene; two results each for benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene; and one result each for thallium, molybdenum, and silver.
- The concentration for selenium in sample EW09-CHN-SC-COMP-01 was re-qualified as a non-detect because of method blank contamination at a concentration of 1.73 mg/kg ww
- All mercury concentrations were J-qualified as estimated because samples were analyzed beyond holding time: 6 months and 20 days after sample collection.
- Non-detected concentrations for two chemicals were Y-qualified by ARI as non-detected at elevated RLs because chromatographic interference in the sample prevented adequate resolution of the compound at the standard RLs. Qualified results included four concentrations for Aroclor 1254 and one concentration for delta-BHC.

5 References

EPA. 1994. USEPA contract laboratory program national functional guidelines for inorganic data review. EPA Publication No. 540/R-94/012. Office of Solid Waste and Emergency Response, US Environmental Protection Agency, Washington, DC.

EPA. 1999. USEPA contract laboratory program national functional guidelines for organic data review. EPA-540/R-99/008. Office of Emergency and Remedial Response, US Environmental Protection Agency, Washington, DC.

EPA. 2002a. Guidance for quality assurance project plans. QA/G-5. EPA/240/R-02/009. Office of Environmental Information, US Environmental Protection Agency, Washington, DC.

EPA. 2002b. USEPA contract laboratory program national functional guidelines for inorganic data review. EPA 540-R-01-008. Office of Emergency and Remedial Response, US Environmental Protection Agency, Washington, DC.

EPA. 2004. USEPA contract laboratory program national functional guidelines for inorganic data review. EPA 540-R-04-004. Office of Emergency and Remedial Response, US Environmental Protection Agency, Washington, DC.

Krone CA, Brown DW, Burrows DG, Bogar RG, Chan S, Varanasi U. 1989. A method for analysis of butyltin species and measurement of butyltins in sediment and English sole livers from Puget Sound. Mar Environ Res 27:1-18.

NOAA. 1993. Tissue lipid determination method. In: Sampling and analytical methods of the National Status and Trends Program national benthic surveillance and mussel watch projects, 1984-1992. Vol 2: Comprehensive descriptions of complementary measurements. NOAA technical memorandum NOS ORCA 71. National Status and Trends Program, National Oceanic and Atmospheric Administration, Silver Spring, MD.

PSEP. 1997. Recommended guidelines for sampling marine sediment, water column, and tissue in Puget Sound. Final report. Prepared for the US Environmental Protection Agency, Seattle, WA. Puget Sound Water Quality Action Team, Olympia, WA.

Ruggerone GT, Volk E. 2004. Residence time and growth of natural and hatchery Chinook salmon in the Duwamish Estuary and Elliott Bay, Washington, based on otolith chemical and structural attributes. Draft. Prepared for US Army Corps of Engineers, Seattle District and Port of Seattle. Natural Resources Consultants, Inc., Seattle, WA.

Shannon J. 2006. Personal communication (e-mails to Matt Luxon, Windward Environmental, regarding Duwamish-Elliott beach seine data collected by Taylor Associates in 1998, 2000, and 2002-2003. Biologist, Taylor Associates, Seattle, WA. March 30, 2006.

WDFW. 2002. Salmonid stock inventory (SaSI) 2002 [online]. Washington Department of Fish and Wildlife, Olympia, WA. [Cited May 2010.] Available from: http://wdfw.wa.gov/fish/sasi/.

Windward. 2008. East Waterway Operable Unit supplemental remedial investigation/feasibility study. Quality assurance project plan: fish and shellfish tissue collection and chemical analysis. Windward Environmental LLC, Seattle, WA.

Windward. 2009. Quality assurance project plan: juvenile Chinook salmon collection and chemical analysis. East Waterway Operable Unit supplemental remedial investigation/feasibility study. Windward Environmental LLC, Seattle, WA.