EAST WATERWAY OPERABLE UNIT
SUPPLEMENTAL REMEDIAL INVESTIGATION/ FEASIBILITY STUDY
FINAL DATA REPORT
FISH AND SHELLFISH TISSUE COLLECTION

For submittal to:

The US Environmental Protection Agency
Region 10
Seattle, WA

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Acronyms

Acronym	Definition
ARI	Analytical Resources, Inc.
BEHP	bis(2-ethylhexyl) phthalate
CAS	Columbia Analytical Services, Inc.
CCV	continuing calibration verification
CFR	Code of Federal Regulations
COC	chain of custody
CVAA	cold vapor atomic absorption
DCM	dichloromethane
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
dw	dry weight
EPA	US Environmental Protection Agency
EW	East Waterway
GC/ECD	gas chromatography/electron capture detector
GC/MS	gas chromatography/mass spectrometry
GFAAS	graphite furnace atomic absorption spectrophotometry
HG/AFS	hydride generation/atomic fluorescence spectrometry
ICP/AES	inductively couple/plasma atomic emission spectrometry
ICP/MS	inductively coupled/plasma mass spectrometry
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
N-qualifier	tentative identification

Acronym	Definition
NAD-83	North American Datum of 1983
PCB	polychlorinated biphenyl
PCP	pentachlorophenol
PSEP	Puget Sound Estuary Program
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
RL	reporting limit
RPD	relative percent difference
SDG	sample delivery group
SVOC	semivolatile organic compound
TBT	tributyltin
U-qualifier	not detected at given concentration
Windward	Windward Environmental LLC
ww	wet weight

1 Introduction

This data report presents the results of chemical analyses of fish, crab, shrimp, and mussel tissue samples collected from August to October of 2008 as part of the supplemental remedial investigation for the East Waterway (EW). Sampling and analyses were conducted in accordance with the fish and shellfish quality assurance project plan (QAPP) (Windward 2008). Field catch results and the results of the chemical analyses of fish, crab, shrimp, and mussel composite tissue samples are provided in this report. Fish and shellfish samples were analyzed for polychlorinated biphenyls (PCBs) as Aroclors, semivolatile organic compounds (SVOCs), total metals, inorganic arsenic, tributyltin (TBT), pesticides, lipids, and total solids. A subset of fish and shellfish samples will be analyzed for PCB congeners and dioxins and furans, but the data are not available for inclusion in this report. Information on the samples selected for the analysis of PCB congeners and dioxins/furans is presented in the tissue selection memorandum (Windward 2009b). The results from these analyses will be provided in a separate data report.

Data collected in this study will be used in both the ecological and human health risk assessments for the following purposes:

1. Characterize exposure of fish and crab receptors of concern to selected chemicals via all exposure routes using a tissue-residue exposure analysis.
2. Characterize exposure of fish, wildlife (birds and mammals), and humans to organic compounds and metals via ingestion of fish and shellfish using dietary exposure estimates.

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

- Appendix A – Data Tables
- Appendix B – Fish Compositing Memorandum
- Appendix C – Data Management
- Appendix D – Data Validation Report
- Appendix E – Laboratory Report Forms
- Appendix F – Field Notes and Field Collection Forms
- Appendix G – Chain-of-Custody (COC) Forms
- Appendix H – Low-Level BEHP and PCP Data Summary
- Appendix I – Super Compositing Memorandum

2 Fish and Shellfish Tissue Collection and Sample Processing Methods

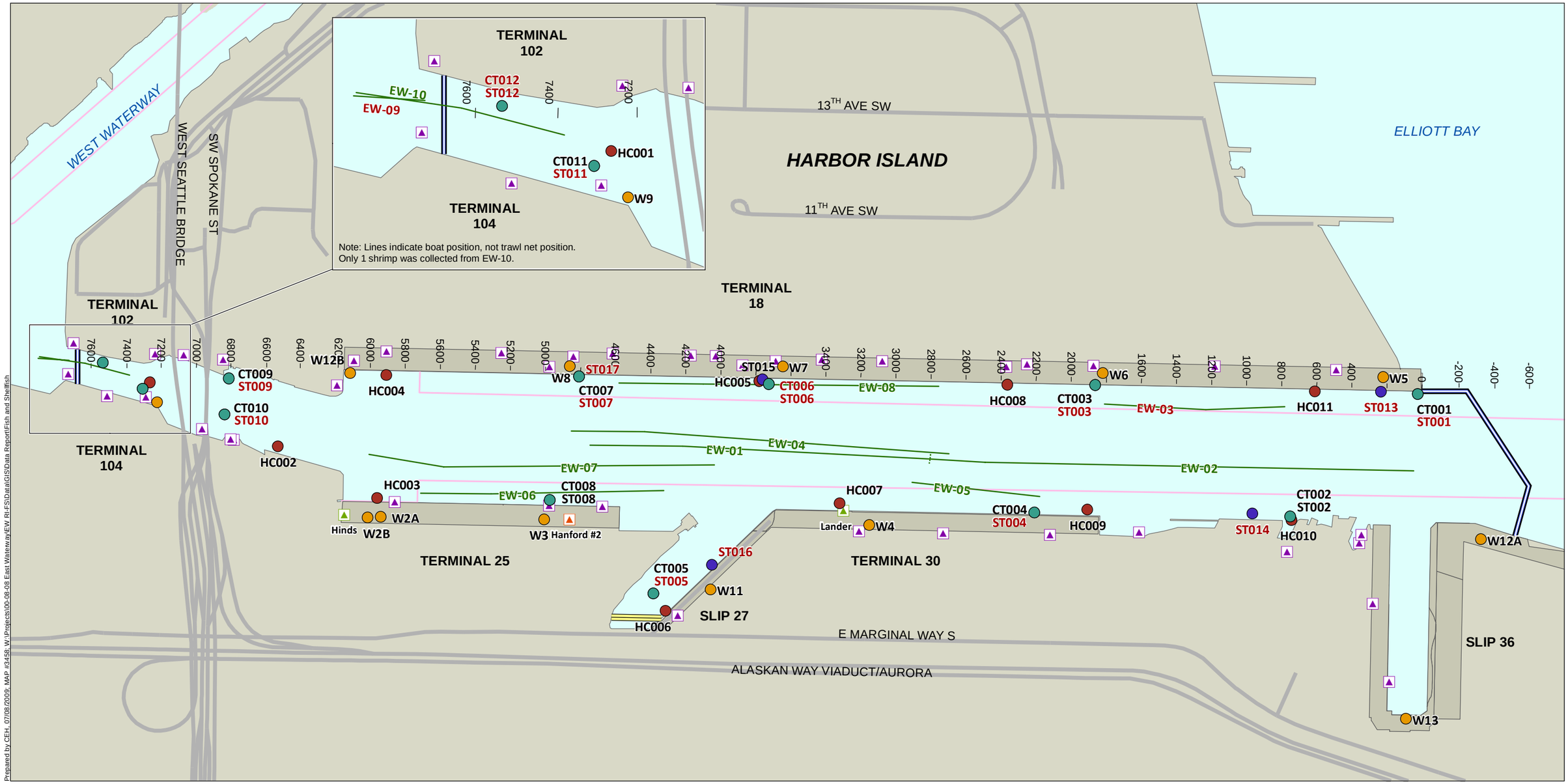
This section summarizes the methods used to collect and process fish, crab, shrimp and mussel tissue samples. The field procedures used to collect these samples are described in detail in the fish and shellfish QAPP (Windward 2008). Section 2.1 presents the fish and shellfish tissue sampling and processing methods; Section 2.2 describes field deviations from the QAPP.

2.1 FISH AND SHELLFISH TISSUE SAMPLING AND PROCESSING

This section discusses the species targeted for collection, sampling methods, and the catch results. Sampling locations are presented on Map 2-1. All sampling was conducted in 2008. Fish, crab, shrimp, and mussel sampling was conducted from August to October. Rockfish were collected by scuba divers from August 11 to 13 and on October 24; crabs and shrimp were collected by traps on August 26 and 27; fish were collected by trawling on September 2; and mussels were collected by hand on August 27.

2.1.1 Targeted species

As presented in Section 3.1 of the QAPP (Windward 2008), species targeted for collection were English sole (≥ 200 mm), shiner surfperch (≥ 80 mm), cancrid crabs (≥ 90 mm), coonstripe shrimp (any size), brown rockfish (≥ 200 mm), and mussels (any size). The minimum target sizes of fish and shellfish were selected to represent the preferred prey size of piscivorous wildlife receptors of concern and reasonable sizes of seafood consumed by humans, as discussed in more detail in the QAPP.



Location type

- Crab trap and shrimp trap[a]
- Shrimp trap
- Mussel
- Rockfish
- Trawl line
- CSO
- Storm Drain
- CSO/Storm Drain
- Dock/Pier
- Road
- Slip 27 Bridge
- Navigation Channel
- East Waterway Study Area Boundary

0 600
Scale in feet

[a] Crabs were collected from crab traps, and shrimp from shrimp traps, with the exception of shrimp trap ST002 which captured three red rock crab. Coordinates for locations CT003/ST003 and CT004/ST004 are approximate.

Note: Location labels in red indicate no larger organisms were captured or retained.

Map 2-1
Fish and Shellfish Sample Locations
Fish and Shellfish Data Report
East Waterway Study Area

2.1.2 Collection methods

Fish and shellfish were collected using four different collection methods: a high-rise otter trawl for all fish species except brown rockfish (which were collected by scuba divers), crab and shrimp traps for crabs and shrimp respectively, and hand collection for mussels. The otter trawl was used to target fish species, although crab and shrimp were also collected during the trawling. Fish and shellfish sampling location coordinates are presented in Table 2-1. The rationale for the sampling locations and the field procedures used to collect the fish and shellfish samples is described in detail in the QAPP (Windward 2008).

Table 2-1. Coordinates for fish and shellfish sampling locations

Collection Method	Sampling Location	Target Species Captured and retained?	Location Coordinates[a]	
			Latitude	Longitude
Otter trawl	EW-01-start	yes	47.57895	-122.344
	EW-01-finish		47.58282	-122.344
	EW-02-start	yes	47.58368	-122.344
	EW-02-finish		47.59038	-122.344
	EW-03-start	no[b]	47.58712	-122.346
	EW-03-finish		47.58553	-122.346
	EW-04-start	yes	47.57835	-122.345
	EW-04-finish		47.58312	-122.344
	EW-05-start	yes	47.58255	-122.344
	EW-05-finish		47.58455	-122.343
	EW-06-start	yes	47.57597	-122.343
	EW-06-finish		47.57867	-122.343
	EW-07-start	yes	47.57522	-122.344
	EW-07-finish		47.57945	-122.344
	EW-08-start	yes	47.57925	-122.346
	EW-08-finish		47.58293	-122.346
	EW-09-start	no[c]	47.56933	-122.346
	EW-09-finish		47.56885	-122.346
	EW-10-start	yes	47.56958	-122.346
	EW-10-finish		47.56887	-122.346

Collection Method	Sampling Location	Target Species Captured and retained?	Location Coordinates[a]	
			Latitude	Longitude
Crab trap	CT001	yes	47.59043	-122.346
	CT002	yes	47.58847	-122.343
	CT003	yes	47.58541	-122.344
	CT004	yes	47.58448	-122.342
	CT005	yes	47.57854	-122.341
	CT006	no[d]	47.58028	-122.346
	CT007	yes	47.57731	-122.346
	CT008	yes	47.57689	-122.343
	CT009	yes	47.57183	-122.346
	CT010	yes	47.57178	-122.345
	CT011	yes	47.57049	-122.345
	CT012	no[d]	47.56986	-122.346
Shrimp trap	ST001	no[d]	47.59043	-122.346
	ST002	yes[e]	47.58847	-122.343
	ST003	no[d]	47.58541	-122.344
	ST004	no[d]	47.58448	-122.342
	ST005	no[d]	47.57854	-122.341
	ST006	no[d]	47.58028	-122.346
	ST007	no[d]	47.57731	-122.346
	ST008	yes	47.57689	-122.343
	ST009	no[d]	47.57183	-122.346
	ST010	no[d]	47.57178	-122.345
	ST011	no[d]	47.57049	-122.345
	ST012	no[d]	47.56986	-122.346
	ST013	no[d]	47.58985	-122.346
	ST014	no[d]	47.58788	-122.343
	ST015	no[d]	47.58018	-122.346
	ST016	no[d]	47.57945	-122.342
	ST017	no[d]	47.57731	-122.346

Collection Method	Sampling Location	Target Species Captured and retained?	Location Coordinates[a]	
			Latitude	Longitude
Hand collection (mussel)	HC001	yes	47.5706	-122.346
	HC002	yes	47.57262	-122.344
	HC003	yes	47.57419	-122.343
	HC004	yes	47.5743	-122.346
	HC005	yes	47.58013	-122.346
	HC006	yes	47.57873	-122.341
	HC007	yes	47.58142	-122.343
	HC008	yes	47.58401	-122.346
	HC009	yes	47.5853	-122.343
	HC010	yes	47.58849	-122.343
	HC011	yes	47.58882	-122.346
Scuba diver (rockfish)	W2A	yes	47.57425	-122.343
	W2B	yes	47.57404	-122.343
	W3	yes	47.5768	-122.343
	W4	yes	47.58189	-122.343
	W5	yes	47.58989	-122.346
	W6	yes	47.5855	-122.346
	W7	yes	47.5805	-122.346
	W8	yes	47.57717	-122.346
	W9	yes	47.57029	-122.346
	W11	yes	47.57923	-122.341
	W12A	yes	47.59145	-122.343
	W12B	yes	47.57373	-122.346
	W13	yes	47.59034	-122.339

[a] NAD-83 horizontal datum.

[b] No fish were captured from the EW-03 trawl.

[c] None of the fish species were retained from the EW-09 trawl because they did not meet the size specifications or sufficient numbers had already been captured.

[d] No shrimp or crabs were captured in these traps.

[e] No shrimp were captured from this shrimp trap, although three red rock crabs were captured and retained.

NAD83 – North American Datum 1983

2.1.2.1 High-rise otter trawl

Trawling was conducted in the EW on September 2, 2008; specifications for the high-rise otter trawl are presented in the QAPP (Windward 2008). All trawling was conducted using the research vessel *Kittiwake*, captained by Charles Eaton (Bio-Marine Enterprises). Target species collected by trawling included English sole, shiner surfperch, Dungeness and red rock crabs, and coonstripe shrimp. Ten trawls were conducted to obtain all target species throughout the EW (see Map 2-1 for trawl locations).

2.1.2.2 Crab and shrimp traps

Crab and shrimp traps were deployed in the EW on August 26 and 27, 2008. Crab traps were Ladner 30-in. rubber-wrapped stainless steel crab traps; shrimp traps were Ladner 30-in. nestable shrimp traps with 0.5-in. mesh. Bait was placed in a mesh bait bag and tied to the inside of each trap so the bags could not be opened and the contents consumed. Bait for crabs consisted of salmon scraps and frozen squid and bait for shrimp consisted of shrimp pellet bait. Target species collected by the traps included Dungeness crab, red rock crab, and coonstripe shrimp.

Twelve crab traps and sixteen shrimp traps were dispersed throughout the EW (Map 2-1). Trap deployment times typically ranged from approximately 4 to 6 hours, with the exception of nine traps that were deployed overnight.

2.1.2.3 Scuba divers

Scuba divers collected brown rockfish divers from August 11 to 13 and on October 24, 2008, at 13 locations (Map 2-1). Divers collected rockfish by using barrier nets and a spear gun. Specifications for diver sampling methods are presented in the QAPP (Windward 2008).

2.1.2.4 Mussel collection

A mussel reconnaissance survey was conducted on July 31, 2008, to determine potential sampling locations in the EW. The locations and abundance of mussels were noted. Mussels were found to be present where ever there was suitable substrate (e.g., pilings and sheetpile walls). Mussels were collected by hand from a boat on August 27, 2008, from 11 locations throughout the EW on pilings or sheetpile (Map 2-1).

2.1.2.5 Field sample processing

After an individual trawl or trap was collected, the catch was sorted by species and size into holding trays that contained site water. Prior to release within their area of capture, non-target species were identified to the lowest practical taxonomic level, numbers of each species were counted (or estimated if a species was present in large numbers), and these data were recorded on the non-target species tally form (Appendix F).

Individual specimens of target fish, crabs, or shrimp were rinsed in site water to remove any foreign matter from the external surface. The target species were then grouped by

species and general size class and placed in clean holding trays to prevent cross contamination. All fish and crabs were inspected carefully to ensure that their skin or shells had not been damaged by the sampling equipment; specimens with broken skin or shells were not included in composite tissue samples. Each fish or crab in the selected target species was measured to determine that the actual total length was greater than or equal to the minimum target length for that species. Large fish were killed by placing them in a ziplock bag and giving them a sharp blow to the head on the side of the processing table. Small fish and shrimp were killed by placing them on ice as recommended by the US Environmental Protection Agency (EPA) (2000). Crabs were killed in the field by placing them on dry ice (Windward 2007). After the target numbers of each species had been obtained, additional specimens of target size captured (but not retained) during sampling were measured, enumerated, and returned to the EW.

Individual specimens of the same species from a particular sampling area and equipment deployment (i.e., a single trawl or trap) were kept together in one large re-sealable plastic bag with the date, time, effort number, species, and collection method recorded on the outside of the bag in indelible ink. Fish and crab that did not meet the targeted size were not retained (≥ 200 mm for English sole and brown rockfish, ≥ 80 mm for shiner surfperch, and ≥ 90 mm for crab). Shrimp and mussels did not have size specifications. The bagged and iced fish, crabs, and shrimp were transported in coolers to Analytical Resources, Inc. (ARI) either that same day or were stored overnight at less than 4˚ C in the Windward Environmental LLC (Windward) processing laboratory and delivered to ARI the following day.

After mussels had been removed from pilings and sheetpile walls, they were rinsed in site water and stored on ice in separate ziplock bags (i.e., one bag per sampling location) and labeled with the date, time, and location identification (ID). The bagged and iced mussels were transported to directly to ARI for processing.

Brown rockfish collected by scuba divers were brought to the surface in collection bags, where they were given to the field crew for processing. Rockfish were weighed and measured in the field. Rockfish that were collected by speargun were killed upon collection. Rockfish collected opportunistically in nets by scuba divers were killed by placing them in a ziplock bag and giving them a sharp blow to the head on the side of the processing table. Individual specimens were placed in separate ziplock bags and labeled with the date, time, and location ID. The specimens were stored on ice and transported to ARI for final processing.

The date, time, and location of each effort were recorded in the field notebook, the target species collection form, and the non-target species tally form. Completed field forms are presented in Appendix F.

2.1.3 Catch results

A total of 292 fish, crab, and shrimp specimens of target species and size were collected and processed from 8 successful trawls, 10 successful crab traps, and 2 successful shrimp traps. A total of 1,075 mussels were collected from throughout EW by hand. Target numbers of fish and shellfish specified in the QAPP (Windward 2008) were met or exceeded for all target species. Catch results for all target fish and shellfish species collected and processed from the EW are presented in Table 2-2. Compositing information, including the specimen ID, length, and weight for each target specimen included in a composite sample, are presented in Appendix B.

Table 2-2. Target species catch results

Target Species	Number of Specimens Retained
English sole	110
Shiner surfperch	80
Brown rockfish	13
Dungeness crab	7
Red rock crab	56
Coonstripe shrimp	26
Mussels	1,075
Total	**1,367**

Non-target fish, crab, shrimp, and other invertebrate species captured in the EW were identified, recorded, and returned to the EW. A total of 23 fish species and 12 types of invertebrates classified to the lowest taxonomic level practicable were collected from the EW, including both target and non-target species. The names and numbers of each species captured by traps or trawls are presented in Table 2-3.

Table 2-3. Numbers of individual species captured in the EW using trawls, crab traps, and shrimp traps

Species	Scientific Name	Number of Specimens Captured			
		Otter Trawl	Crab Trap	Shrimp Trap	Total
American shad	*Alosa sapidissima*	3	0	0	3
Bay goby	*Lepidogobius lepidus*	31	0	0	31
Brown rockfish	*Sebastes auriculatus*	2	3	3	8[a]
Decorator crab	*Loxorhynchus crispatus*	3	0	0	3
Dungeness crab	*Cancer magister*	10	4	0	14
Coonstripe shrimp	*Pandalus danae*	17	0	9	26
English sole	*Parophrys vetulus*	610	0	0	610

Species	Scientific Name	Number of Specimens Captured			
		Otter Trawl	Crab Trap	Shrimp Trap	Total
Flathead sole	*Hippoglossoides elassodon*	8	0	0	8
Great sculpin	*Myoxocephalus polyacanthocephalus*	2	0	0	2
Kelp crab	*Pugettia producta*	1	0	0	1
Longfin smelt	*Spirinchus thaleichthys*	5	0	0	5
Pacific herring	*Clupea pallasii marisalbi*	29	0	0	29
Pacific sanddab	*Citharichthys sordidus*	12	0	0	12
Pacific staghorn sculpin	*Leptocottus armatus*	38	0	2	40
Pacific Tomcod	*Microgadus proximus*	234	0	0	234
Plainfin midshipman	*Porichthys notatus*	82	0	0	82
Plumose anemone	*Metridium senile*	38	0	0	38
Pygmy rock crab	*Cancer oregensis*	3	0	0	3
Rat fish	*Hydrolagus colliei*	14	0	0	14
Red rock crab	*Cancer productus*	6	63	25	94
Rock sole	*Lepidopsetta bilineata*	33	0	0	33
Sand sole	*Psettichthys melanostictus*	46	0	0	46
Sea star	*Evasterias sp*	12	0	0	12
Sea star	*Luidia sp.*	3	0	0	3
Sea star, sunflower	*Pycnopodia helianthoides*	1	1	0	2
Shiner surfperch	*Cymatogaster aggregata*	199	0	0	199
Slender crab	*Cancer gracilis*	7	1	3	11
Slender sole	*Lyopsetta exilis*	1	0	0	1
Snake prickleback	*Lumpenus sagitta*	2	0	0	2
Solaster star	*Solaster stimpsoni*	0	3	2	5
Speckled sanddab	*Citharichthys stigmaeus*	11	0	0	11
Spotted greenling	*Hexagrammos stelleri*	1	0	0	1
Starry flounder	*Platichthys stellatus*	18	0	0	18
Urchin	*Echinodermata sp.*	1	0	0	1
Warbonnet	*Chirolophis decoratus*	1	0	0	1
Total		**1,484**	**75**	**44**	**1,616**

[a] An additional 13 brown rockfish were collected by scuba divers.

2.1.4 Sample processing, identification, and compositing

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

2.1.4.1 Laboratory sample processing

At the end of each day, all sample labels were checked against field forms, and sample ID numbers were recorded on COC forms. COC forms were placed together with samples collected that day. Prior to transport to ARI, samples were securely packed inside a cooler with ice packs and were kept on ice. Samples were delivered to ARI either that same day or were stored overnight at less than 4°C in the Windward processing laboratory and delivered to the laboratory the following day. Following compositing and homogenization at ARI, frozen tissue subsamples were shipped via UPS to Brooks Rand and CAS.

Initial processing of samples (i.e., weighing, measuring, and packaging) was conducted by Windward personnel at ARI. Fish and crab were weighed using an analytical scale accurate to 0.1 g wet weight, measured, and individually packaged. Each target specimen was individually wrapped in heavy-duty aluminum foil, enclosed in a resealable plastic bag with an ID label (also enclosed in a resealable bag). Shrimp and mussels were weighed and then packaged by sampling location. Crabs and rockfish were double-wrapped in heavy-duty aluminum foil to minimize punctures prior to placing them in the plastic bag. Rockfish gender was determined at ARI according to procedures in the QAPP (Windward 2008) prior to packaging.

All relevant information for each individually wrapped and labeled specimen was recorded on the target fish and crab species collection forms (Appendix F). Relevant information included the specimen ID, length, weight, gender (when differences between the sexes were visually discernable, such as with gravid females), sampling date, time, and location number. Samples were kept frozen at ARI at -20°C until the fish compositing scheme was determined.

Fish composite samples were created and fish were homogenized at ARI. All fish and shellfish tissue preparation, including filleting of fish, dissection of crabs, removal of whole-body mussel tissue from the shells, and homogenization of tissues, was conducted following ARI's standard operating procedures as specified in the QAPP (Windward 2008). Specimens were grouped for composite samples prior to homogenization (see Section 2.1.4.3 and Appendix B). Large fish were chopped into small pieces and included in their entirety in the composite sample. For fillet samples, partially thawed whole fish were filleted (skin on), and the fillets were then homogenized. Crabs were dissected, and the hepatopancreas and edible-meat tissues were combined into the relevant composite samples prior to homogenization (Appendix B). Mussels were removed from their shells prior to homogenization.

2.1.4.2 Sample identification

Unique alphanumeric sample IDs were assigned to each individual target fish or crab specimen and recorded on the target fish and crab species form (Appendix F). Shrimp and mussels were grouped as multiple specimens according to trawl or trap location;

these combined specimens were assigned unique alphanumeric sample IDs based on sampling location.Table 2-4 presents the ID scheme for fish and shellfish specimens.

Table 2-4. Identification scheme for fish and shellfish specimens

Identifier	Description
EW	Identifies the project area.
08	Identifies the year in which the sample was collected.
TR, CT, ST, SCUBA, or HC followed by sequential three-digit number	Identifies the collection method (trawl, crab trap, shrimp trap, scuba diver, or hand collection, respectively) and the effort as a unique number over all areas (e.g., the 15th trawl after the start of sampling would be TR015).
ES, SS, DC, RR, SR, BR,[a] or MS	Identifies the species type (English sole, shiner surfperch, Dungeness crab, red rock crab, shrimp, brown rockfish, or mussel, respectively).
Sequential number	Identifies the order in which a specimen (or group of specimens for shrimp and mussels) was captured during the sampling event.

[a] Eight specimens were identified with "RF" instead of "BR." Sample IDs were corrected after delivery to ARI.

EW – East Waterway

Thus, for example, the 28th English sole captured in the 5th trawl was identified as EW-08-TR05-ES-028. After individual fish and shellfish specimens (or groups of specimens for shrimp and mussels) were combined to form composite samples, as discussed in Section 2.1.4.3, composite sample IDs were assigned as shown in Table 2-5.

Table 2-5. Identification scheme for fish and shellfish composite tissue samples

Identifier	Description
EW	Identifies the project area.
08	Identifies the year in which the samples were collected.
ES, SS, DC, RR, SR, or MS	Identifies the species type (English sole, shiner surfperch, Dungeness crab, red rock crab, shrimp, or mussel, respectively).
WB, FL, EM, or HP	Identifies whole-body, fillet, edible-meat, or hepatopancreas samples, respectively.
comp	Indicates the sample as a composite of individual specimens.
sequential number	Identifies the composite number for a specific species.

Thus, for example, the second composite whole-body English sole sample was identified as EW-08-ES-WB-comp2.

2.1.4.3 Compositing scheme

Fish (except brown rockfish) and shellfish 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 (Windward 2009a). Most of the specimens retained for

analysis were included in composite samples. Rockfish were not composited but were instead analyzed as 13 individual whole body samples. The numbers and types of composite samples created and chemically analyzed are presented in Table 2-6.

Table 2-6. Numbers of fish and shellfish composite tissue samples collected

Species[a]	Total Length (mm)	Sample Type	No. of Composite Tissue Samples	No. of Specimens per Sample
English sole	≥ 200	whole body	11	5
		fillet (skin on)	11	5
Shiner surfperch	≥ 80	whole body	8	10
Dungeness crab	≥ 90	edible meat	1	7
		hepatopancreas	1	7
Red rock crab	≥ 90	edible meat	8	7
		hepatopancreas	8	7
Shrimp	any size	whole body	1	26
Mussel	any size	whole body (soft tissue only)	11	89 –101

[a] Brown rockfish are not included in this table because they were analyzed as 13 individual samples.

English sole, shiner surfperch, and crab specimens were evenly distributed among composites based on specimen weights, genders, and collection locations of a given species. The first step in this distribution process was to divide all specimens into three size categories based on the weight distribution of the specimens, with equal weight intervals in each size category. Each composite sample then received approximately the same number of specimens from each size class. In addition, specimens of different genders and from different locations were distributed as evenly as possible among the composite samples. All shrimp collected were included in one composite sample because there was insufficient numbers and mass to create more than one composite sample. Brown rockfish collected were analyzed as individuals rather than as composite samples as specified in the QAPP. Mussels were composited by location collected. A summary of each of the composite samples is presented in Table 2-7. Comprehensive compositing information, including length and weight data for each individual specimen included in the composite samples and gender data, is presented in Appendix B. Individual rockfish ranged in length from 193 to 310 mm.

Super composites were created for English sole fillet, English sole whole body, shiner surfperch, mussels, crab edible meat, and crab hepatopancreas. These composites were created by combining the existing composites for each species and tissue type. A detailed discussion of the creation of the super composites is provided in Appendix I.

Table 2-7. Summary of composite tissue samples

Species	Sample IDs	Number of Individuals	Average Length (mm)	Minimum Length (mm)	Maximum Length (mm)
English sole whole body	EW-08-ES-WB-comp1	5	230	202	285
	EW-08-ES-WB-comp2	5	235	201	308
	EW-08-ES-WB-comp3	5	237	202	298
	EW-08-ES-WB-comp4	5	233	200	285
	EW-08-ES-WB-comp5	5	237	195	313
	EW-08-ES-WB-comp6	5	230	200	280
	EW-08-ES-WB-comp7	5	227	200	275
	EW-08-ES-WB-comp8	5	233	205	271
	EW-08-ES-WB-comp9	5	230	209	259
	EW-08-ES-WB-comp10	5	225	197	250
	EW-08-ES-WB-comp11	5	227	204	243
English sole fillet	EW-08-ES-FL-comp1	5	253	205	355
	EW-08-ES-FL-comp2	5	249	207	348
	EW-08-ES-FL-comp3	5	245	208	351
	EW-08-ES-FL-comp4	5	244	201	342
	EW-08-ES-FL-comp5	5	236	208	280
	EW-08-ES-FL-comp6	5	235	208	285
	EW-08-ES-FL-comp7	5	235	200	273
	EW-08-ES-FL-comp8	5	228	205	266
	EW-08-ES-FL-comp9	5	229	201	259
	EW-08-ES-FL-comp10	5	227	209	252
	EW-08-ES-FL-comp11	5	231	200	259
English sole total		**110**	**234**	**195**	**355**
Shiner surfperch	EW-08-SS-WB-comp1	10	112	97	131
	EW-08-SS-WB-comp2	10	114	105	131
	EW-08-SS-WB-comp3	10	112	102	129
	EW-08-SS-WB-comp4	10	112	104	125
	EW-08-SS-WB-comp5	10	112	100	125
	EW-08-SS-WB-comp6	10	112	104	123
	EW-08-SS-WB-comp7	10	113	105	123
	EW-08-SS-WB-comp8	10	115	100	132
Shiner surfperch total		**80**	**113**	**97**	**132**

Species	Sample IDs	Number of Individuals	Average Length (mm)	Minimum Length (mm)	Maximum Length (mm)
Dungeness crab	EW-08-DC-EM-comp1 EW-08-DC-HP-comp1	7	147	127	161
Dungeness crab total		**7**	**147**	**127**	**161**
Red rock crab	EW-08-RR-EM-comp1 EW-08-RR-HP-comp1	7	133	106	164
	EW-08-RR-EM-comp2 EW-08-RR-HP-comp2	7	137	110	157
	EW-08-RR-EM-comp3 EW-08-RR-HP-comp3	7	136	120	156
	EW-08-RR-EM-comp4 EW-08-RR-HP-comp4	7	139	120	154
	EW-08-RR-EM-comp5 EW-08-RR-HP-comp5	7	141	123	157
	EW-08-RR-EM-comp6 EW-08-RR-HP-comp6	7	138	120	156
	EW-08-RR-EM-comp7 EW-08-RR-HP-comp7	7	137	110	153
	EW-08-RR-EM-comp8 EW-08-RR-HP-comp8	7	132	113	149
Red rock crab total		**56**	**137**	**106**	**164**
Coonstripe shrimp	EW-08-SR-WB-comp1	26	na	na	na
Coonstripe shrimp total		**26**	na	na	na
Mussel	EW-08-MS-WB-comp1	89	na	na	na
	EW-08-MS-WB-comp2	93	na	na	na
	EW-08-MS-WB-comp3	91	na	na	na
	EW-08-MS-WB-comp4	100	na	na	na
	EW-08-MS-WB-comp5	101	na	na	na
	EW-08-MS-WB-comp6	101	na	na	na
	EW-08-MS-WB-comp7	100	na	na	na
	EW-08-MS-WB-comp8	100	na	na	na
	EW-08-MS-WB-comp9	100	na	na	na
	EW-08-MS-WB-comp10	100	na	na	na
	EW-08-MS-WB-comp11	100	na	na	na
Mussel total		**1,075**	na	na	na

Note: Brown rockfish are not included in the table because they were analyzed as individuals rather than as composite samples. Lengths of individual rockfish ranged from 193 to 310 mm, as presented in Appendix B.

na – not applicable (lengths were not measured for coonstripe shrimp or mussels)

A small number of the specimens collected were not used in creating composite tissue samples because they were not needed to meet the target number of specimens for a particular sample. These specimens included six English sole and four red rock crab.

2.2 FIELD DEVIATIONS FROM THE QAPP

Field deviations from the QAPP (Windward 2008) included minor modifications to collection and processing methods. These field deviations did not affect the data quality and are discussed in detail below.

- All specimen IDs for brown rockfish used "SCUBA" instead of "SB" and eight specimen IDs contained "RF" instead of "BR." Sample IDs were corrected after delivery to ARI.
- The target length for brown rockfish was 200 mm. One rockfish retained for chemical analysis had a length of 193 mm because it was killed during capture and could not be released.
- The target length for English sole was 200 mm. Two English sole retained for chemical analysis had lengths of 195 and 197 mm. These fish were included in the whole-body composite samples EW-08-ES-WB-comp5 and EW-08-ES-WB-comp10, respectively. Including these two English soles in composite samples was approved by EPA in the fish and shellfish compositing memorandum.
- The QAPP specified that rockfish would be collected in August. Slip 36 was not initially a target location because of the US Coast Guard's strict access regulations. However, Coast Guard granted access to collect rockfish from Slip 36 in October.
- The Washington State Department of Fish and Wildlife permit changed after the QAPP went final to account for higher numbers of shiner surfperch and mussels noted in the field. The number of mussels was increased from 140 to 1,100, and the number of shiner surfperch was increased from 60 to 85 because the abundance of both species in the EW was much greater than originally expected.

3 Analytical Methods

The methods and procedures used to prepare and chemically analyze the composite tissue samples are described briefly in this section and in detail in the QAPP (Windward 2008). 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 (PSEP 1997; EPA 2002a).

3.1 FISH AND SHELLFISH TISSUE ANALYTICAL METHODS

Individual fish and shellfish specimens were homogenized into composite tissue samples at ARI according to the compositing scheme presented in the fish compositing

memorandum (Windward 2009a, b). Windward personnel oversaw the initial homogenization procedures to ensure that the correct specimens were included in the composite tissue samples. Individual specimens used in each composite tissue sample are presented in Appendix B.

All composite tissue samples and whole-body rockfish tissue samples were analyzed for PCBs as Aroclors, SVOCs, phthalates, polycyclic aromatic hydrocarbons (PAHs), low-level PAHs, total metals, inorganic arsenic, TBT, pesticides, lipids, and total solids, with the following exceptions. Because of limited sample mass, the coonstripe shrimp composite tissue sample was only analyzed for total metals, SVOCs, PCBs as Aroclors, lipids, and total solids. In addition, rockfish sample EW-08-SB002-BR-01, English sole whole-body sample EW-08-ES-WB-comp2, and two crab hepatopancreas samples (EW-08-DC-HP-comp1 and EW-08-RR-HP-comp6) were not analyzed for low-level PAHs because of limited sample mass. The whole-body rockfish tissue samples were reanalyzed to achieve lower reporting limits for bis(2-ethylhexyl) phthalate (BEHP) and pentachlorophenol (PCP) at ARI. The results are presented in Section 4.1.5. In addition, for English sole, shiner surfperch, crab edible meat, crab hepatopancreas, and mussel tissue super composite samples were created by combining all the original composite samples for each species to create new composite samples that were submitted for low-level BEHP and PCP analysis. Results for the super composite samples are presented in Appendix H.

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

Table 3-1. Analytical methods for fish and shellfish tissue analyses

Parameter	Method	Reference	Maximum Sample Holding Time	Method of Preservation	Laboratory
PCBs as Aroclors	GC/ECD	EPA 8082	1 year to extract, 40 days to analyze	freeze/-20 °C	CAS
Organochlorine pesticides[a]	GC/ECD	EPA 8081A	1 year to extract, 40 days to analyze	freeze/-20 °C	ARI
SVOCs including PAHs[b]	GC/MS	EPA 8270D	1 year to extract, 40 days to analyze	freeze/-20 °C	ARI
Low-level PAHs	GC/MS-SIM	EPA 8270C-SIM	1 year to extract, 40 days to analyze	freeze/-20°C	CAS
Low-level BEHP	GC/MS-SIM	EPA 8270D-SIM	1 year to extract, 40 days to analyze	freeze/-20°C	ARI
Low-level PCP	GC/ECD	EPA 8041	1 year to extract, 40 days to analyze	freeze/-20°C	ARI

Parameter	Method	Reference	Maximum Sample Holding Time	Method of Preservation	Laboratory
Inorganic arsenic	HG-AFS	EPA 1632	6 months[c]	freeze/-20 °C	Brooks Rand Labs
Total arsenic	ICP-MS with DRC	EPA 1638	6 months[c]	freeze/-20°C	Brooks Rand Labs
Total metals[c]	ICP-MS and ICP-AES	EPA 6020 and EPA 6010B	6 months[c]	freeze/-20 °C	ARI
Mercury	CVAA	EPA 7471	6 months	freeze/-20 °C	ARI
Tributyltin, dibutyltin, monobutyltin (as ions)	GC/MS-SIM	Krone et al. (1989)	1 year to extract, 40 days to analyze	freeze/-20 °C	ARI
Lipids	DCM: acetone extraction gravimetric	NOAA (1993)	1 year	freeze/-20 °C	ARI
Total solids	freeze-dried	PSEP (1986) or EPA 160.2	6 months	freeze/-20 °C	ARI

[a] Target pesticides include: 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, hexachlorobenzene, methoxychlor, mirex, and toxaphene.

[b] Target PAHs include: 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] Tissue samples were frozen to extend the maximum holding time to 1 year.

[d] Arsenic, antimony, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc**.**

ARI – Analytical Resources, Inc.BEHP – bis(2-ethylhexyl) phthalate

CAS – Columbia Analytical Services, Inc.

CVAA – cold vapor atomic absorption

DCM – dichloromethane

DDD – dichlorodiphenyldichloroethane

DDE – dichlorodiphenyldichloroethylene

DDT – dichlorodiphenyltrichloroethane

EPA – US Environmental Protection Agency

GC/ECD – gas chromatography/electron capture detector

GC/MS – gas chromatography/mass spectrometry

HG-AFS – hydride generation/atomic fluorescence spectrometry

ICP-AES – inductively couple/plasma atomic emission spectrometry

ICP-MS – inductively coupled/plasma mass spectrometry

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyls

PCP – pentachlorophenol

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:

- The QAPP (Windward 2008) specified that total metals would be analyzed by ARI using inductively coupled plasma-atomic emission spectrometry (ICP-AES), inductively coupled plasma-mass spectrometry (ICP-MS), or graphite furnace atomic absorption (GFAA) per EPA Methods 6010B, 6020, or 7000 series, respectively, within 6 months of sample collection. Total metals were analyzed by ARI using EPA 6010B and EPA 200.8, which is equivalent to EPA 6020.
- In consultation with the EPA QA office, total arsenic was also analyzed in the fish and shellfish tissue samples by Brooks Rand Labs using Dynamic Reaction Cell (DRC) with ICP-MS per EPA Method 1638, in addition to total arsenic analysis by ARI as specified in the QAPP (Windward 2008). This laboratory and test method was selected to minimize potential matrix interferences in the tissue samples and to ensure comparability by having a single laboratory generate both the total and inorganic arsenic results. The total arsenic results from both laboratories were similar; the results from Brooks Rand Labs are presented in this data report and the project database. All samples were analyzed for total metals and inorganic arsenic within the laboratories' standard holding times of one year for frozen tissues, which is consistent with PSEP guidance (PSEP 1997), rather than the 6 month holding time that was listed in the QAPP (Windward 2008).
- PCBs as Aroclors were analyzed in all tissue samples at CAS, per EPA agreement (Sanga 2009) instead of ARI as specified in the QAPP (Windward 2008).
- Butyltins were analyzed using gas chromatography/mass spectrometry with selective ion monitoring by (Krone et al. 1989). The QAPP (Windward 2008) listed butyltin analysis using gas chromatography/flame photometric detection in error. The quality of the data is not affected by this deviation.

4 Results of Chemical Analyses

This section presents results of the chemical analyses and data validation of the fish and shellfish tissue samples. Laboratory report forms are presented in Appendix E. The approach used to average laboratory replicates and the methods for calculating concentrations of total PCBs are presented in Appendix C.

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 D.

4.1 TISSUE CHEMISTRY RESULTS

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

4.1.1 Metals

Table 4-1 presents a summary of the metals analyzed in fish and shellfish tissue samples, including the number of detections, the range of detected concentrations, and the range of reporting limit (RLs). Lead and thallium are the only metals not presented in Table 4-1 because neither was detected in any tissue types, at RLs ranging from 0.4 to 0.8 mg/kg ww and 0.004 to 0.008 mg/kg ww, respectively. Results are discussed for total arsenic, inorganic arsenic, cadmium, chromium, copper, mercury, nickel, silver, and zinc. Data tables for these metals and the remaining seven metals are presented in Appendix A for each sample of each tissue type. The total and inorganic arsenic results presented in this section were reported by Brooks Rand Labs; the remaining metals results were reported by ARI.

Table 4-1. Summary of detected metals in fish and shellfish tissue composite samples and brown rockfish individual tissue sampes

Species by Chemical	Detection Frequency	Detected Concentration (mg/kg ww)		Reporting Limits (mg/kg ww)
		Minimum	Maximum	
Antimony				
Mussel – whole body	9/11	0.004 J	0.010 J	0.004
Coonstripe shrimp – whole body	0/1	nd	nd	0.008
Dungeness crab – edible meat	0/1	nd	nd	0.008
Dungeness crab – hepatopancreas	0/1	nd	nd	0.008
Red rock crab – edible meat	1/8	0.004	0.004	0.004
Red rock crab – hepatopancreas	8/8	0.006	0.016	na
Brown rockfish – whole body	0/13	nd	nd	0.004
English sole – fillet with skin	0/11	nd	nd	0.004
English sole – whole body	4/11	0.004	0.005	0.004 – 0.008
Shiner surfperch – whole body	0/8	nd	nd	0.008
Arsenic (total)				
Mussel – whole body	11/11	0.616	1.14	na
Coonstripe shrimp – whole body	1/1	4.42	4.42	na
Dungeness crab – edible meat	1/1	7.30	7.30	na
Dungeness crab – hepatopancreas	1/1	6.04	6.04	na
Red rock crab – edible meat	8/8	4.33	5.44	na
Red rock crab – hepatopancreas	8/8	2.93	4.40	na
Brown rockfish – whole body	13/13	0.531	1.24	na
English sole – fillet with skin	11/11	3.43	8.23	na
English sole – whole body	11/11	2.97	4.18	na

Species by Chemical	Detection Frequency	Detected Concentration (mg/kg ww)		Reporting Limits (mg/kg ww)
		Minimum	Maximum	
Shiner surfperch – whole body	8/8	0.493	1.24	na
Arsenic (inorganic)				
Mussel – whole body	11/11	0.040	0.133	na
Dungeness crab – edible meat	1/1	0.043	0.043	na
Dungeness crab – hepatopancreas	1/1	0.046	0.046	na
Red rock crab – edible meat	8/8	0.020	0.038	na
Red rock crab – hepatopancreas	8/8	0.038	0.089	na
Brown rockfish – whole body	13/13	0.004	0.023	na
English sole – fillet with skin	0/11	nd	nd	0.007 – 0.009
English sole – whole body	11/11	0.023	0.059	na
Shiner surfperch – whole body	8/8	0.012	0.037	na
Cadmium				
Mussel – whole body	11/11	0.19	0.66	na
Coonstripe shrimp – whole body	1/1	0.17	0.17	na
Dungeness crab – edible meat	1/1	0.09	0.09	na
Dungeness crab – hepatopancreas	1/1	0.37	0.37	na
Red rock crab – edible meat	8/8	0.57	0.98	na
Red rock crab – hepatopancreas	8/8	4.18	6.85	na
Brown rockfish – whole body	0/13	nd	nd	0.08
English sole – fillet with skin	1/11	0.11	0.11	0.04
English sole – whole body	1/11	0.04	0.04	0.04
Shiner surfperch – whole body	0/8	nd	nd	0.04 – 0.08
Chromium				
Mussel – whole body	11/11	0.1	0.2	na
Coonstripe shrimp – whole body	1/1	0.5	0.5	na
Dungeness crab – edible meat	0/1	nd	nd	0.1
Dungeness crab – hepatopancreas	0/1	nd	nd	0.1
Red rock crab – edible meat	7/8	0.1	0.1	0.1
Red rock crab – hepatopancreas	8/8	0.1	0.2	na
Brown rockfish – whole body	13/13	0.3	0.6	na
English sole – fillet with skin	5/11	0.1	0.1	0.1
English sole – whole body	11/11	0.3	0.4	na
Shiner surfperch – whole body	6/8	0.2	0.4	0.2
Cobalt				
Mussel – whole body	9/11	0.06	0.08	0.06
Coonstripe shrimp – whole body	0/1	nd	nd	0.1
Dungeness crab – edible meat	1/1	0.17	0.17	na
Dungeness crab – hepatopancreas	1/1	0.32	0.32	na
Red rock crab – edible meat	8/8	0.09	0.13	na
Red rock crab – hepatopancreas	8/8	0.21	0.40	na

Species by Chemical	Detection Frequency	Detected Concentration (mg/kg ww)		Reporting Limits (mg/kg ww)
		Minimum	Maximum	
Brown rockfish – whole body	0/13	nd	nd	0.1
English sole – fillet with skin	0/11	nd	nd	0.06
English sole – whole body	0/11	nd	nd	0.06
Shiner surfperch – whole body	0/8	nd	nd	0.06 – 0.1
Copper				
Mussel – whole body	11/11	1.22	2.63	na
Coonstripe shrimp – whole body	1/1	26.4	26.4	na
Dungeness crab – edible meat	1/1	15.8	15.8	na
Dungeness crab – hepatopancreas	1/1	31.1	31.1	na
Red rock crab – edible meat	8/8	10.8	15.9	na
Red rock crab – hepatopancreas	8/8	43.6	58.5	na
Brown rockfish – whole body	13/13	0.43	2.42	na
English sole – fillet with skin	11/11	0.28	1.47	na
English sole – whole body	11/11	0.79	2.11	na
Shiner surfperch – whole body	8/8	1.08	3.16	na
Mercury				
Mussel – whole body	1/11	0.01	0.01	0.009 – 0.01
Coonstripe shrimp – whole body	1/1	0.03	0.03	na
Dungeness crab – edible meat	1/1	0.15	0.15	na
Dungeness crab – hepatopancreas	1/1	0.077	0.077	na
Red rock crab – edible meat	8/8	0.042	0.076	na
Red rock crab – hepatopancreas	8/8	0.02	0.032	na
Brown rockfish – whole body	13/13	0.04	0.418	na
English sole – fillet with skin	11/11	0.038	0.07	na
English sole – whole body	11/11	0.030	0.042	na
Shiner surfperch – whole body	8/8	0.036	0.05	na
Molybdenum				
Mussel – whole body	11/11	0.3	0.4	na
Coonstripe shrimp – whole body	1/1	0.5	0.5	na
Dungeness crab – edible meat	1/1	0.3	0.3	na
Dungeness crab – hepatopancreas	1/1	0.3	0.3	na
Red rock crab – edible meat	8/8	0.3	0.4	na
Red rock crab – hepatopancreas	8/8	0.4	0.5	na
Brown rockfish – whole body	6/13	0.2	0.4	0.2
English sole – fillet with skin	11/11	0.2	0.3	na
English sole – whole body	7/11	0.1	0.3	0.1
Shiner surfperch – whole body	5/8	0.2	0.4	0.1
Nickel				
Mussel – whole body	0/11	nd	nd	0.2
Coonstripe shrimp – whole body	1/1	2.3	2.3	na

Species by Chemical	Detection Frequency	Detected Concentration (mg/kg ww)		Reporting Limits (mg/kg ww)
		Minimum	Maximum	
Dungeness crab – edible meat	0/1	nd	nd	0.2
Dungeness crab – hepatopancreas	0/1	nd	nd	0.2
Red rock crab – edible meat	5/8	0.2 J	0.4	0.2
Red rock crab – hepatopancreas	2/8	0.4	0.4	0.2
Brown rockfish – whole body	0/13	nd	nd	0.4
English sole – fillet with skin	1/11	0.4 J	0.4 J	0.2
English sole – whole body	8/11	0.2 J	1.0	0.2
Shiner surfperch – whole body	0/8	nd	nd	0.2 – 0.4
Selenium				
Mussel – whole body	11/11	0.37	0.60	na
Coonstripe shrimp – whole body	1/1	0.5 J	0.5 J	na
Dungeness crab – edible meat	1/1	0.9 J	0.9 J	na
Dungeness crab – hepatopancreas	1/1	1.3 J	1.3 J	na
Red rock crab – edible meat	8/8	0.7	1.21	na
Red rock crab – hepatopancreas	8/8	1.07	1.60	na
Brown rockfish – whole body	13/13	0.50	0.85	na
English sole – fillet with skin	11/11	0.47	0.67	na
English sole – whole body	11/11	0.5	0.68	na
Shiner surfperch – whole body	8/8	0.3	0.6 J	na
Silver				
Mussel – whole body	0/11	nd	nd	0.06
Coonstripe shrimp – whole body	1/1	0.2 J	0.2 J	na
Dungeness crab – edible meat	1/1	0.18 J	0.18 J	na
Dungeness crab – hepatopancreas	1/1	0.53 J	0.53 J	na
Red rock crab – edible meat	8/8	0.11 J	0.16 J	na
Red rock crab – hepatopancreas	8/8	0.28 J	0.48 J	na
Brown rockfish – whole body	0/13	nd	nd	0.1
English sole – fillet with skin	0/11	nd	nd	0.06
English sole – whole body	0/11	nd	nd	0.06
Shiner surfperch – whole body	0/8	nd	nd	0.06 – 0.1
Vanadium				
Mussel – whole body	11/11	0.16	0.42	na
Coonstripe shrimp – whole body	1/1	0.3	0.3	na
Dungeness crab – edible meat	1/1	0.06	0.06	na
Dungeness crab – hepatopancreas	1/1	0.11	0.11	na
Red rock crab – edible meat	2/8	0.07	0.08	0.06
Red rock crab – hepatopancreas	8/8	0.13	0.62	na
Brown rockfish – whole body	0/13	nd	nd	0.1
English sole – fillet with skin	0/11	nd	nd	0.06
English sole – whole body	11/11	0.28	0.49	na

Species by Chemical	Detection Frequency	Detected Concentration (mg/kg ww)		Reporting Limits (mg/kg ww)
		Minimum	Maximum	
Shiner surfperch – whole body	4/8	0.15	0.28	0.1
Zinc				
Mussel – whole body	11/11	11.5	22.2	na
Coonstripe shrimp – whole body	1/1	16.9	16.9	na
Dungeness crab – edible meat	1/1	40.8	40.8	na
Dungeness crab – hepatopancreas	1/1	23.5	23.5	na
Red rock crab – edible meat	8/8	39.4	59.5	na
Red rock crab – hepatopancreas	8/8	32.8	58.1	na
Brown rockfish – whole body	13/13	13.7	21.0	na
English sole – fillet with skin	11/11	8.6	13.0	na
English sole – whole body	11/11	13.8	16.3	na
Shiner surfperch – whole body	8/8	21.2	26.8	na

Note: Chemicals that were not detected in any tissue types were not included in this table. Chemicals that were not detected were lead and thallium.

J – estimated concentration

na – not applicable

nd – not detected

ww – wet weight

Total arsenic was detected in all samples at concentrations ranging from 0.49 to 8.23 mg/kg ww. Concentrations were lowest in brown rockfish, mussels, and shiner surfperch (0.493 to 1.24 mg/kg ww) and higher in other species (2.93 to 8.23).

Inorganic arsenic was detected in all sample types except for English sole fillet samples. Concentrations ranged from 0.004 to 0.133 mg/kg ww. In general, the lowest concentrations were in brown rockfish samples (0.004 to 0.023 mg/kg ww). Table 4-2 presents a summary of the percent inorganic arsenic concentrations relative to total arsenic concentrations found in fish and shellfish tissue samples, including the number of inorganic arsenic detections and the range of percent inorganic arsenic. Percent inorganic arsenic ranged from 0.43 to 16%. The higest percent inorganic arsenic was found in mussel composite tissue samples, ranging from 4.5 to 16%.

Table 4-2 Summary of percent inorganic arsenic in fish and shellfish composite tissue samples and brown rockfish individual tissue sampes

Species and Tissue Type	Detection Frequency[a]	% Inorganic Arsenic	
		Minimum	Maximum
Mussel – whole body	11/11	4.5	16
Coonstripe shrimp – whole body	na	na	na
Dungeness crab – edible meat	1/1	0.59	0.59
Dungeness crab – hepatopancreas	1/1	0.76	0.76
Red rock crab – edible meat	8/8	0.43	0.83

Species and Tissue Type	Detection Frequency[a]	% Inorganic Arsenic	
		Minimum	Maximum
Red rock crab – hepatopancreas	8/8	0.94	2.2
Brown rockfish – whole body	13/13	0.65	2.1
English sole – fillet with skin	0/11	nc	nc
English sole – whole body	11/11	0.59	1.6
Shiner surfperch – whole body	8/8	1.0	3.2

[a] Detection frequency is based on inorganic arsenic concentrations. Total arsenic was detected in all samples.

na – inorganic arsenic not analyzed in this sample because of insufficient sample mass.

nc – not calculated

Cadmium was detected in all shellfish (i.e., shrimp, crab, and mussel) samples but was detected in only one English sole whole-body sample, one English sole fillet sample, and none of the brown rockfish or shiner surfperch samples. In shellfish tissue, concentrations were highest in red rock crab hepatopancreas samples (4.18 to 6.85 mg/kg ww) and lower in other shellfish tissue types (0.09 to 0.98 mg/kg ww).

Chromium was detected in most tissue samples. Concentrations ranged from 0.1 to 0.2 mg/kg ww in English sole fillet, mussels, and red rock crab edible meat and hepatopancreas and from 0.2 to 0.6 mg/kg ww in the remaining tissue types.

Copper was detected in all tissue samples. Concentrations ranged from 0.28 to 3.16 mg/kg ww in rockfish, English sole (fillet and edible meat), mussels, and shiner surfperch samples and from 10.8 to 58.5 mg/kg ww in shrimp and crab (edible meat and hepatopancreas) samples. Concentrations were higher in crab hepatopancreas than edible meat samples.

Mercury was detected in all samples of all tissue types, except mussels, in which mercury was only detected in 1 of 11 samples. Detected concentrations ranged from 0.01 to 0.418 mg/kg ww. The highest concentrations were detected in rockfish samples.

Nickel was infrequently detected in most tissues, and detected concentrations ranged from 0.2 to 2.3 mg/kg ww. Nickel was most frequently detected in English sole whole-body samples (8 out of 11 samples).

Silver was detected only in shrimp and crab at concentrations ranging from 0.11 to 0.53 mg/kg ww. Concentrations were higher in crab hepatopancreas than edible-meat samples.

Zinc was detected in all samples at concentrations ranging from 8.6 to 59.5 mg/kg ww. Concentrations were generally higher in crab hepatopancreas and edible-meat samples (23.5 to 59.5 mg/kg ww) than other tissue types (8.6 to 26.8 mg/kg ww).

4.1.2 Butyltins

Table 4-3 presents a summary of the detected butyltins analyzed in fish and shellfish tissue samples, including the number of detections, the range of detected butyltin concentrations, and the range of RLs. The shrimp sample was not analyzed for butlytins because of insufficient sample mass. Monobutyltin was not detected in any tissue samples at RLs ranging from 6.9 to 8.2 µg/kg ww. TBT was detected in at least one sample of all tissue types except Dungeness crab edible meat and red rock crab edible meat and hepatopancreas. TBT concentrations were generally lowest in mussels and English sole fillets (7.5 to 17 µg/kg ww) and highest in brown rockfish (38 to 420 µg/kg ww). Dibutyltin was detected only in four brown rockfish samples and one Dungeness crab hepatopancreas sample at concentrations ranging from 11 to 24 µg/kg ww).

Table 4-3. Summary of detected butyltins in fish and shellfish composite tissue samples and brown rockfish individual samples

Species by Chemical	Detection Frequency	Detected Concentration (µg/kg ww)		Reporting Limits (µg/kg ww)
		Minimum	Maximum	
Dibutyltin as Ion				
Mussel – whole body	0/11	nd	nd	9.9 – 12
Dungeness crab – edible meat	0/1	nd	nd	10
Dungeness crab – hepatopancreas	1/1	11	11	na
Red rock crab – edible meat	0/8	nd	nd	12
Red rock crab – hepatopancreas	0/8	nd	nd	11 – 12
Brown rockfish – whole body	4/13	13	24	10 – 51
English sole – fillet with skin	0/11	nd	nd	12
English sole – whole body	0/11	nd	nd	9.9 – 11
Shiner surfperch – whole body	0/8	nd	nd	9.8 – 11
Tributyltin as Ion				
Mussel – whole body	10/11	7.5	17	7.7
Dungeness crab – edible meat	0/1	nd	nd	6.8
Dungeness crab – hepatopancreas	1/1	23	23	na
Red rock crab – edible meat	0/8	nd	nd	7.7
Red rock crab – hepatopancreas	0/8	nd	nd	7.6 – 7.7
Brown rockfish – whole body	13/13	38	420	na
English sole – fillet with skin	5/11	8.0	14	7.7
English sole – whole body	11/11	17	38	na
Shiner surfperch – whole body	8/8	30 J	67	na

Note: Monobutyltin results were not included in this table because they were not detected in any samples.

J – estimated concentration

na – not applicable

nd – not detected

ww – wet weight

4.1.3 Phthalates

Table 4-4 presents a summary of the diethyl phthalate results for fish and shellfish composite tissue samples, including the number of detections, the range of detected concentrations, and the range of RLs. Of the six phthalates analyzed, diethyl phthalate was the only phthalate detected in fish and shellfish samples. It was detected in only one English sole fillet composite sample at a concentration of 410 µg/kg ww. RLs for other phthalates ranged from 200 to 4,900 µg/kg ww. Rockfish samples were analyzed for low-level BEHP with no detected results and RLs that ranged from 16 to 150 µg/kg ww (see Appendix A for details). Fish and shellfish tissue super composite samples were analyzed for low-level BEHP. Results for low-level BEHP testing for the super composite samples are presented in Appendix H. BEHP was not detected in any of the samples with RLs that ranged from 37-240 µg/kg ww.

Table 4-4. Summary of detected phthalates in fish and shellfish composite tissue samples and brown rockfish individual tissue samples

Species by Chemical	Detection Frequency	Detected Concentration (µg/kg ww)		Reporting Limits (µg/kg ww)
		Minimum	Maximum	
Diethyl Phthalate				
Mussel – whole body	0/11	nd	nd	200
Coonstripe shrimp – whole body	0/1	nd	nd	330
Dungeness crab – edible meat	0/1	nd	nd	330
Dungeness crab – hepatopancreas	0/1	nd	nd	330
Red rock crab – edible meat	0/8	nd	nd	200
Red rock crab – hepatopancreas	0/8	nd	nd	330 – 450
Brown rockfish – whole body	0/13	nd	nd	330
English sole – fillet with skin	1/11	410	410	330
English sole – whole body	0/11	nd	nd	200
Shiner surfperch – whole body	0/8	nd	nd	1,300

Note: Other phthalate compounds were not included in this table because they were not detected in any tissue type (BEHP, butyl benzyl phthalate, dimethyl phthalate, di-n-butyl phthalate, and di-n-octyl phthalate).

BEHP – bis(2-ethylhexyl) phthalate

nd – not detected

RL – reporting limit

ww – wet weight

4.1.4 PAHS

Fish and shellfish tissue composite samples were analyzed for PAHs using EPA Method 8270D and then reanalyzed using EPA Method 8270C-SIM for low-level PAHs. Table 4-5 presents a summary of the detected low-level PAHs, the range of detected concentrations, and the range of RLs. Twenty-five PAHs were detected in fish and shellfish tissue samples. 2-Chloronaphthalene was not a target analyte for the low-level PAH analysis; therefore, the results for this analyte reflect the original analysis. No

PAHs were detected in coonstripe shrimp whole-body and Dungeness crab hepatopancreas samples. Data tables for PAHs are presented in Appendix A for each sample of each tissue type. The results of the low-level analysis have been selected to replace the original results in all cases.

Table 4-5. Summary of detected low-level PAHs in fish and shellfish composite tissue samples and brown rockfish individual tissue samples

Species by Chemical	Detection Frequency	Detected Concentration (µg/kg ww)		Reporting Limits (µg/kg ww)
		Minimum	Maximum	
1-Methylnaphthalene				
Brown rockfish – whole body	12/13	1.5	3.0	330
Coonstripe shrimp – whole body	0/1	nd	nd	330
Dungeness crab – edible meat	0/1	nd	nd	2.5
Dungeness crab – hepatopancreas	0/1	nd	nd	330
English sole – fillet with skin	7/11	0.43 J	0.70	0.49 – 0.74
English sole – whole body	4/11	0.54	0.88	2.4 – 200
Mussel – whole body	11/11	0.52	0.97	na
Red rock crab – edible meat	1/8	0.47 J	0.47 J	0.48 – 0.50
Red rock crab – hepatopancreas	5/8	0.81	2.7	0.49 – 330
Shiner surfperch – whole body	8/8	1.3	3.1	na
2-Methylnaphthalene				
Brown rockfish – whole body	12/13	2.0	3.7	330
Coonstripe shrimp – whole body	0/1	nd	nd	330
Dungeness crab – edible meat	0/1	nd	nd	5.0
Dungeness crab – hepatopancreas	0/1	nd	nd	330
English sole – fillet with skin	6/11	0.69 J	0.96 J	0.96 – 1.5
English sole – whole body	4/11	0.72 J	1.1	4.7 – 200
Mussel – whole body	9/11	0.68 J	1.4	0.94 – 1.0
Red rock crab – edible meat	1/8	0.87 J	0.87 J	0.95 – 1.0
Red rock crab – hepatopancreas	5/8	1.1	2.4	0.97 – 330
Shiner surfperch – whole body	8/8	1.4 J	3.1	na
Acenaphthene				
Brown rockfish – whole body	12/13	1.5	8.5 J	330
Coonstripe shrimp – whole body	0/1	nd	nd	330
Dungeness crab – edible meat	1/1	2.3 J	2.3 J	na
Dungeness crab – hepatopancreas	0/1	nd	nd	330
English sole – fillet with skin	11/11	0.83	3.6	na
English sole – whole body	10/11	1.5	5.0	200
Mussel – whole body	11/11	1.2	5.8	na
Red rock crab – edible meat	8/8	0.45 J	1.7	na
Red rock crab – hepatopancreas	7/8	2.0	16	330

Species by Chemical	Detection Frequency	Detected Concentration (µg/kg ww)		Reporting Limits (µg/kg ww)
		Minimum	Maximum	
Shiner surfperch – whole body	8/8	4.8	7.5	na
Acenaphthylene				
Brown rockfish – whole body	12/13	0.25 J	1.2	330
Coonstripe shrimp – whole body	0/1	nd	nd	330
Dungeness crab – edible meat	0/1	nd	nd	2.5
Dungeness crab – hepatopancreas	0/1	nd	nd	330
English sole – fillet with skin	11/11	0.14 J	0.30 J	na
English sole – whole body	10/11	0.37 J	1.2 J	200
Mussel – whole body	11/11	0.38 J	3.4	na
Red rock crab – edible meat	4/8	0.074 J	0.086 J	0.48 – 0.50
Red rock crab – hepatopancreas	7/8	0.22 J	0.75 J	330
Shiner surfperch – whole body	8/8	0.27 J	1.7	na
Anthracene				
Brown rockfish – whole body	10/13	0.35 J	3.4	0.50 – 330
Coonstripe shrimp – whole body	0/1	nd	nd	330
Dungeness crab – edible meat	0/1	nd	nd	2.5
Dungeness crab – hepatopancreas	0/1	nd	nd	330
English sole – fillet with skin	11/11	0.30 J	0.58	na
English sole – whole body	10/11	1.1	25	200
Mussel – whole body	11/11	1.5	23	na
Red rock crab – edible meat	8/8	0.32 J	1.1	na
Red rock crab – hepatopancreas	7/8	2.1	6.6	330
Shiner surfperch – whole body	8/8	0.38 J	2.1	na
Benzo(a)anthracene				
Brown rockfish – whole body	0/13	nd	nd	0.49 – 330
Coonstripe shrimp – whole body	0/1	nd	nd	330
Dungeness crab – edible meat	0/1	nd	nd	2.5
Dungeness crab – hepatopancreas	0/1	nd	nd	330
English sole – fillet with skin	1/11	0.35 J	0.35 J	0.47 – 0.74
English sole – whole body	2/11	1.1	5.9	0.49 – 200
Mussel – whole body	11/11	4.8	95	na
Red rock crab – edible meat	3/8	0.83	1.6	0.50 – 0.67
Red rock crab – hepatopancreas	6/8	2.5	5.8	7.4 – 330
Shiner surfperch – whole body	2/8	2.9	4.8	0.91 – 4.0
Benzo(a)pyrene				
Brown rockfish – whole body	0/13	nd	nd	0.49 – 330
Coonstripe shrimp – whole body	0/1	nd	nd	330
Dungeness crab – edible meat	1/1	1.5 J	1.5 J	na
Dungeness crab – hepatopancreas	0/1	nd	nd	330

Species by Chemical	Detection Frequency	Detected Concentration (µg/kg ww)		Reporting Limits (µg/kg ww)
		Minimum	Maximum	
English sole – fillet with skin	1/11	0.16 J	0.16 J	0.47 – 0.74
English sole – whole body	5/11	1.0	7.9	0.49 – 200
Mussel – whole body	11/11	1.7	70	na
Red rock crab – edible meat	2/8	0.12 J	0.14 J	0.48 – 0.50
Red rock crab – hepatopancreas	6/8	0.34 J	0.59	2.4 – 330
Shiner surfperch – whole body	1/8	0.68 J	0.68 J	0.77 – 3.7
Benzo(b)fluoranthene				
Brown rockfish – whole body	0/13	nd	nd	0.49 – 330
Coonstripe shrimp – whole body	0/1	nd	nd	330
Dungeness crab – edible meat	1/1	2.2 J	2.2 J	na
Dungeness crab – hepatopancreas	0/1	nd	nd	330
English sole – fillet with skin	2/11	0.15 J	0.21 J	0.47 – 0.74
English sole – whole body	8/11	1.8 J	12	0.49 – 200
Mussel – whole body	11/11	8.7	140	na
Red rock crab – edible meat	2/8	0.28 J	0.39 J	0.48 – 0.50
Red rock crab – hepatopancreas	7/8	0.88	3.3	330
Shiner surfperch – whole body	6/8	0.38 J	3.2	1.1 – 3.7
Benzo(g,h,i)perylene				
Brown rockfish – whole body	0/13	nd	nd	0.49 – 330
Coonstripe shrimp – whole body	0/1	nd	nd	330
Dungeness crab – edible meat	1/1	1.0 J	1.0 J	na
Dungeness crab – hepatopancreas	0/1	nd	nd	330
English sole – fillet with skin	2/11	0.067 J	0.089 J	0.47 – 0.74
English sole – whole body	9/11	0.18 J	4.5	0.49 – 200
Mussel – whole body	11/11	1.5	25	na
Red rock crab – edible meat	3/8	0.077 J	0.12 J	0.48 – 0.50
Red rock crab – hepatopancreas	7/8	0.21 J	0.71 J	330
Shiner surfperch – whole body	6/8	0.15 J	1.2 J	1.1 – 3.7
Benzo(k)fluoranthene				
Brown rockfish – whole body	0/13	nd	nd	0.49 – 330
Coonstripe shrimp – whole body	0/1	nd	nd	330
Dungeness crab – edible meat	1/1	1.9 J	1.9 J	na
Dungeness crab – hepatopancreas	0/1	nd	nd	330
English sole – fillet with skin	3/11	0.11 J	0.18 J	0.49 – 0.74
English sole – whole body	8/11	0.79	3.1	0.49 – 200
Mussel – whole body	11/11	3.6	49	na
Red rock crab – edible meat	1/8	0.13 J	0.13 J	0.48 – 0.50
Red rock crab – hepatopancreas	7/8	0.27 J	0.93 J	330
Shiner surfperch – whole body	5/8	0.28 J	2.1	0.82 – 3.7

Species by Chemical	Detection Frequency	Detected Concentration (µg/kg ww)		Reporting Limits (µg/kg ww)
		Minimum	Maximum	
Total benzofluoranthenes				
Brown rockfish – whole body	0/13	nd	nd	na
Coonstripe shrimp – whole body	0/1	nd	nd	na
Dungeness crab – edible meat	1/1	4.1 J	4.1 J	na
Dungeness crab – hepatopancreas	0/1	nd	nd	na
English sole – fillet with skin	3/11	0.18 J	0.32 J	na
English sole – whole body	8/11	2.7 J	15	na
Mussel – whole body	11/11	12.5	190	na
Red rock crab – edible meat	2/8	0.28 J	0.52 J	na
Red rock crab – hepatopancreas	7/8	1.24 J	4.2 J	na
Shiner surfperch – whole body	6/8	0.38 J	5.3	na
Chrysene				
Brown rockfish – whole body	0/13	nd	nd	0.49 – 330
Coonstripe shrimp – whole body	0/1	nd	nd	330
Dungeness crab – edible meat	0/1	nd	nd	2.5
Dungeness crab – hepatopancreas	0/1	nd	nd	330
English sole – fillet with skin	0/11	nd	nd	0.47 – 0.74
English sole – whole body	2/11	1.5	10	0.49 – 200
Mussel – whole body	11/11	11	240	na
Red rock crab – edible meat	5/8	0.31 J	1.6	0.50
Red rock crab – hepatopancreas	6/8	1.9	6.5	13 – 330
Shiner surfperch – whole body	2/8	2.6	3.0	0.82 – 4.0
Dibenzo(a,h)anthracene				
Brown rockfish – whole body	0/13	nd	nd	0.49 – 330
Coonstripe shrimp – whole body	0/1	nd	nd	330
Dungeness crab – edible meat	1/1	0.60 J	0.60 J	na
Dungeness crab – hepatopancreas	0/1	nd	nd	330
English sole – fillet with skin	0/11	nd	nd	0.47 – 0.74
English sole – whole body	8/11	0.19 J	1.2	0.49 – 200
Mussel – whole body	11/11	0.36 J	8.1	na
Red rock crab – edible meat	0/8	nd	nd	0.48 – 0.50
Red rock crab – hepatopancreas	6/8	0.071 J	0.61 J	0.49 – 330
Shiner surfperch – whole body	3/8	0.28 J	1.0	0.77 – 3.7
Dibenzofuran				
Brown rockfish – whole body	12/13	0.80	4.3 J	330
Coonstripe shrimp – whole body	0/1	nd	nd	330
Dungeness crab – edible meat	1/1	1.8 J	1.8 J	na
Dungeness crab – hepatopancreas	0/1	nd	nd	330
English sole – fillet with skin	11/11	0.43 J	1.5	na

Species by Chemical	Detection Frequency	Detected Concentration (µg/kg ww)		Reporting Limits (µg/kg ww)
		Minimum	Maximum	
English sole – whole body	10/11	0.65	2.0 J	200
Mussel – whole body	11/11	0.89	4.0	na
Red rock crab – edible meat	8/8	0.91	2.4	na
Red rock crab – hepatopancreas	7/8	3.2	13	330
Shiner surfperch – whole body	8/8	2.3	4.5	na
Fluoranthene				
Brown rockfish – whole body	0/13	nd	nd	0.49 – 330
Coonstripe shrimp – whole body	0/1	nd	nd	330
Dungeness crab – edible meat	0/1	nd	nd	7.6
Dungeness crab – hepatopancreas	0/1	nd	nd	330
English sole – fillet with skin	11/11	0.39 J	1.6	na
English sole – whole body	1/11	3.0	3.0	2.7 – 200
Mussel – whole body	11/11	17	100	na
Red rock crab – edible meat	8/8	0.83	8.6	na
Red rock crab – hepatopancreas	6/8	9.4	37	69 – 330
Shiner surfperch – whole body	1/8	5.8	5.8	2.2 – 4.7
Fluorene				
Brown rockfish – whole body	12/13	0.99	3.0	330
Coonstripe shrimp – whole body	0/1	nd	nd	330
Dungeness crab – edible meat	1/1	1.9 J	1.9 J	na
Dungeness crab – hepatopancreas	0/1	nd	nd	330
English sole – fillet with skin	11/11	0.43 J	1.1	na
English sole – whole body	10/11	1.1	2.4 J	200
Mussel – whole body	11/11	1.4	7.0	na
Red rock crab – edible meat	8/8	1.3	3.1	na
Red rock crab – hepatopancreas	7/8	3.9	23	330
Shiner surfperch – whole body	8/8	2.2	4.8	na
Indeno(1,2,3-cd)pyrene				
Brown rockfish – whole body	0/13	nd	nd	0.49 – 330
Coonstripe shrimp – whole body	0/1	nd	nd	330
Dungeness crab – edible meat	1/1	1.4 J	1.4 J	na
Dungeness crab – hepatopancreas	0/1	nd	nd	330
English sole – fillet with skin	2/11	0.10 J	0.13 J	0.48 – 0.74
English sole – whole body	9/11	0.19 J	5.8	0.49 – 200
Mussel – whole body	11/11	1.6	37	na
Red rock crab – edible meat	1/8	0.10 J	0.10 J	0.48 – 0.50
Red rock crab – hepatopancreas	7/8	0.18 J	0.83 J	330
Shiner surfperch – whole body	5/8	0.23 J	1.8	0.82 – 3.7
Naphthalene				

Species by Chemical	Detection Frequency	Detected Concentration (µg/kg ww)		Reporting Limits (µg/kg ww)
		Minimum	Maximum	
Brown rockfish – whole body	12/13	2.0	4.7 J	330
Coonstripe shrimp – whole body	0/1	nd	nd	330
Dungeness crab – edible meat	0/1	nd	nd	5.0
Dungeness crab – hepatopancreas	0/1	nd	nd	330
English sole – fillet with skin	0/11	nd	nd	1.5 – 2.9
English sole – whole body	0/11	nd	nd	1.7 – 200
Mussel – whole body	0/11	nd	nd	0.94 – 1.7
Red rock crab – edible meat	1/8	3.1	3.1	1.4 – 2.8
Red rock crab – hepatopancreas	3/8	3.2	4.4	1.3 – 330
Shiner surfperch – whole body	0/8	nd	nd	2.5 – 5.8
Perylene				
Brown rockfish – whole body	0/12	nd	nd	0.49 – 0.64
Dungeness crab – edible meat	0/1	nd	nd	2.5
English sole – fillet with skin	0/11	nd	nd	0.47 – 0.74
English sole – whole body	1/10	3.3	3.3	0.49 – 2.5
Mussel – whole body	11/11	0.61	21	na
Red rock crab – edible meat	1/8	0.11 J	0.11 J	0.48 – 0.50
Red rock crab – hepatopancreas	6/7	0.21 J	0.65	2.4
Shiner surfperch – whole body	0/8	nd	nd	0.77 – 3.7
Phenanthrene				
Brown rockfish – whole body	0/13	nd	nd	0.85 – 330
Coonstripe shrimp – whole body	0/1	nd	nd	330
Dungeness crab – edible meat	0/1	nd	nd	2.5
Dungeness crab – hepatopancreas	0/1	nd	nd	330
English sole – fillet with skin	11/11	0.45 J	1.5	na
English sole – whole body	8/11	1.2	14	2.4 – 200
Mussel – whole body	11/11	6.6	38	na
Red rock crab – edible meat	8/8	1.1	4.3	na
Red rock crab – hepatopancreas	7/8	5.3	30	330
Shiner surfperch – whole body	8/8	2.5	5.6	na
Pyrene				
Brown rockfish – whole body	0/13	nd	nd	0.49 – 330
Coonstripe shrimp – whole body	0/1	nd	nd	330
Dungeness crab – edible meat	0/1	nd	nd	2.5
Dungeness crab – hepatopancreas	0/1	nd	nd	330
English sole – fillet with skin	11/11	0.23 J	0.59	na
English sole – whole body	1/11	1.8	1.8	0.98 – 200
Mussel – whole body	11/11	8.4	51	na
Red rock crab – edible meat	8/8	0.67	2.6	na
Red rock crab – hepatopancreas	6/8	6.4	18	15 – 330

Species by Chemical	Detection Frequency	Detected Concentration (µg/kg ww)		Reporting Limits (µg/kg ww)
		Minimum	Maximum	
Shiner surfperch – whole body	1/8	4.0	4.0	0.82 – 4.7
Total HPAHs				
Brown rockfish – whole body	0/13	nd	nd	na
Coonstripe shrimp – whole body	0/1	nd	nd	na
Dungeness crab – edible meat	1/1	8.6 J	8.6 J	na
Dungeness crab – hepatopancreas	0/1	nd	nd	na
English sole – fillet with skin	11/11	0.62 J	2.6 J	na
English sole – whole body	9/11	0.37 J	50	na
Mussel – whole body	11/11	59 J	820	na
Red rock crab – edible meat	8/8	1.50	15.3 J	na
Red rock crab – hepatopancreas	7/8	6.4 J	68 J	na
Shiner surfperch – whole body	6/8	0.53 J	23.8 J	na
Total LPAHs				
Brown rockfish – whole body	12/13	6.0 J	19.2	na
Coonstripe shrimp – whole body	0/1	nd	nd	na
Dungeness crab – edible meat	1/1	4.2 J	4.2 J	na
Dungeness crab – hepatopancreas	0/1	nd	nd	na
English sole – fillet with skin	11/11	2.39 J	7.0 J	na
English sole – whole body	10/11	5.5 J	32 J	na
Mussel – whole body	11/11	11.3	66	na
Red rock crab – edible meat	8/8	3.2 J	12.7 J	na
Red rock crab – hepatopancreas	7/8	13.5 J	80	na
Shiner surfperch – whole body	8/8	10.2 J	21.6	na
cPAHs – mammal – half DL				
Brown rockfish – whole body	0/13	nd	nd	na
Coonstripe shrimp – whole body	0/1	nd	nd	na
Dungeness crab – edible meat	1/1	2.40 J	2.40 J	na
Dungeness crab – hepatopancreas	0/1	nd	nd	na
English sole – fillet with skin	3/11	0.320 J	0.420 J	na
English sole – whole body	9/11	0.450 J	11.2	na
Mussel – whole body	11/11	3.80 J	108	na
Red rock crab – edible meat	5/8	0.400 J	0.510 J	na
Red rock crab – hepatopancreas	7/8	0.960 J	2.40 J	na
Shiner surfperch – whole body	6/8	0.760 J	2.22	na
Total PAHs				
Brown rockfish – whole body	12/13	6.0 J	19.2	na
Coonstripe shrimp – whole body	0/1	nd	nd	na
Dungeness crab – edible meat	1/1	12.8 J	12.8 J	na
Dungeness crab – hepatopancreas	0/1	nd	nd	na

Species by Chemical	Detection Frequency	Detected Concentration (µg/kg ww)		Reporting Limits (µg/kg ww)
		Minimum	Maximum	
English sole – fillet with skin	11/11	3.14 J	9.6 J	na
English sole – whole body	10/11	5.5 J	58	na
Mussel – whole body	11/11	70 J	880	na
Red rock crab – edible meat	8/8	4.7 J	22.4 J	na
Red rock crab – hepatopancreas	7/8	36.4 J	136 J	na
Shiner surfperch – whole body	8/8	11.7 J	45.4 J	na

cPAH – carcinogenic polycyclic aromatic hydrocarbon

HPAH – high-molecular-weight polycyclic aromatic hydrocarbon

J – estimated concentration

LPAH – low-molecular-weight polycyclic aromatic hydrocarbon

na – not applicable

nd – not detected

PAH – polycyclic aromatic hydrocarbon

ww – wet weight

4.1.5 Other SVOCs

Table 4-6 presents a summary of the detected SVOCs analyzed in fish and shellfish tissue samples, including the number of detections, the range of detected concentrations, and the range of RLs. Only three SVOCs were detected in all of the fish and shellfish samples. 1,4-Dichlorobenzene was detected in one English sole whole-body composite sample at a concentration of 4,800 µg/kg ww. Benzoic acid was detected in all mussel whole-body composite samples at concentrations ranging from 3,100 to 6,400 µg/kg ww. Phenol was detected in all red rock crab hepatopancreas samples at concentrations ranging from 470 to 1,400 µg/kg ww.

Rockfish samples were analyzed for low-level PCP; all results were non-detected with RLs ranging from 3.9 to 4.1 µg/kg ww (Appendix A). Fish and shellfish tissue super composite samples were also analyzed for low-level PCP. PCP was not detected in any of the super composite samples with RLs ranging from 3.9 to 11 µg/kg ww (Appendix H).

In general, RLs SVOCs range from 200 to 330 µg/kg ww, with the exception of shiner surfperch composite samples which had elevated RLs for these chemicals (1,300 µg/kg ww). Most RLs for phenols and some other SVOCs that are known to be difficult to quantify at low concentrations (e.g., benzoic acid) are generally higher, ranging from 990 to 1,700 µg/kg ww or 6,700 µg/kg ww in shiner surfperch samples. Shiner surfperch samples were analyzed with a higher analytical dilution because of higher lipid content relative to other tissue types; hence, RLs are elevated. The RLs are compared to ACGs in Section 4.3.

Table 4-6. Summary of detected SVOCs in fish and shellfish composite tissue samples and brown rockfish individual tissue samples

Species by Chemical	Detection Frequency	Detected Concentration (µg/kg ww)		Reporting Limits (µg/kg ww)
		Minimum	Maximum	
1,4-Dichlorobenzene				
Mussel – whole body	0/11	nd	nd	200
Coonstripe shrimp – whole body	0/1	nd	nd	330
Dungeness crab – edible meat	0/1	nd	nd	330
Dungeness crab – hepatopancreas	0/1	nd	nd	330
Red rock crab – edible meat	0/8	nd	nd	200
Red rock crab – hepatopancreas	0/8	nd	nd	330
Brown rockfish – whole body	0/13	nd	nd	330
English sole – fillet with skin	0/11	nd	nd	330
English sole – whole body	1/11	4,800	4,800	200
Shiner surfperch – whole body	0/8	nd	nd	1,300
Benzoic Acid				
Mussel – whole body	11/11	3,100	6,400	na
Coonstripe shrimp – whole body	0/1	nd	nd	3,300
Dungeness crab – edible meat	0/1	nd	nd	3,300
Dungeness crab – hepatopancreas	0/1	nd	nd	3,300
Red rock crab – edible meat	0/7	nd	nd	2,000
Red rock crab – hepatopancreas	0/8	nd	nd	3,300
Brown rockfish – whole body	0/13	nd	nd	3,300
English sole – fillet with skin	0/11	nd	nd	3,300
English sole – whole body	0/11	nd	nd	2,000
Shiner surfperch – whole body	0/8	nd	nd	13,000
Phenol				
Mussel – whole body	0/11	nd	nd	200
Coonstripe shrimp – whole body	0/1	nd	nd	330
Dungeness crab – edible meat	0/1	nd	nd	330
Dungeness crab – hepatopancreas	0/1	nd	nd	330
Red rock crab – edible meat	0/8	nd	nd	200
Red rock crab – hepatopancreas	8/8	470	1,400	na
Brown rockfish – whole body	0/13	nd	nd	330
English sole – fillet with skin	0/11	nd	nd	330
English sole – whole body	0/11	nd	nd	200
Shiner surfperch – whole body	0/8	nd	nd	1,300

Note: Other SVOCs are not included in this table because they were not detected in any tissue types.

na – not applicable

nd – not detected

SVOC – semivolatile organic compound

ww – wet weight

4.1.6 PCB Aroclors

Table 4-7 presents a summary of PCB concentrations for each tissue type, including the number of detections, the range of detected concentrations, and the range of RLs. Results are included for individual Aroclors as well as total PCBs calculated as the sum of detected Aroclors. Aroclor 1254 and 1260 were the only Aroclors detected in EW tissue samples: Aroclors 1254 was detected in at least one tissue sample of each species and tissue type, and Aroclor 1260 was detected in every tissue sample. The concentrations of total PCBs were lowest in mussels (ranging from 19 to 44 µg/kg ww). Of the three fish species, total concentrations were generally lower in shiner surfperch (380 to 1,200 µg/kg ww) than in English sole (1,500 to 5,000 µg/kg ww) and brown rockfish (400 to 4,3000 µg/kg ww). Total PCB concentrations in crab edible-meat samples were lower (48 to 210 µg/kg ww) than concentrations in hepatopancreas samples (310 to 2,000 µg/kg ww).

Table 4-7. Summary of detected PCBs (as individual Aroclors and Aroclor sums) in fish and shellfish composite tissue samples and brown rockfish individual tissue samples

Species by Chemical	Detection Frequency	Detected Concentration (µg/kg ww)		Reporting Limits (µg/kg ww)[a]
		Minimum	Maximum	
Aroclor 1254				
Mussel – whole body	0/11	nd	nd	19 – 42
Coonstripe shrimp – whole body	1/1	240	240	na
Dungeness crab – edible meat	1/1	85	85	na
Dungeness crab – hepatopancreas	1/1	910	910	na
Red rock crab – edible meat	1/8	54 J	54 J	20 – 50
Red rock crab – hepatopancreas	1/8	130	130	80 – 280
Brown rockfish – whole body	5/13	770	1,100	150 – 1,600
English sole – fillet with skin	11/11	240	1,000	na
English sole – whole body	11/11	700	2,400	na
Shiner surfperch – whole body	8/8	140 JN	640	na
Aroclor 1260				
Mussel – whole body	11/11	19 JN	44 J	na
Coonstripe shrimp – whole body	1/1	220 J	220 J	na
Dungeness crab – edible meat	1/1	92	92	na
Dungeness crab – hepatopancreas	1/1	1,000	1,000	na
Red rock crab – edible meat	8/8	48 J	160	na
Red rock crab – hepatopancreas	8/8	310 J	550	na
Brown rockfish – whole body	13/13	400 J	4,300	na
English sole – fillet with skin	11/11	250	960	na
English sole – whole body	11/11	760	2,600	na

Species by Chemical	Detection Frequency	Detected Concentration (µg/kg ww)		Reporting Limits (µg/kg ww)[a]
		Minimum	Maximum	
Shiner surfperch – whole body	8/8	240	600	na
Total PCBs[b]				
Mussel – whole body	11/11	19 JN	44 J	na
Coonstripe shrimp – whole body	1/1	460 J	460 J	na
Dungeness crab – edible meat	1/1	177	177	na
Dungeness crab – hepatopancreas	1/1	2,000	2,000	na
Red rock crab – edible meat	8/8	48 J	210 J	na
Red rock crab – hepatopancreas	8/8	310 J	550	na
Brown rockfish – whole body	13/13	400 J	4,300	na
English sole – fillet with skin	11/11	530	2,000	na
English sole – whole body	11/11	1,500	5,000	na
Shiner surfperch – whole body	8/8	380 JN	1,200	na

Note: Aroclor 1016, Aroclor 1221, Aroclor 1232, Aroclor 1242, and Aroclor 1248 are not included in this table because they were not detected in any tissue types.

[a] Range of reporting limits for non-detect samples.

[b] The method for calculating total PCBs is presented in Appendix C.

J – estimated concentration

JN – tentatively identified with an estimated concentration

na – not applicable

PCB – polychlorinated biphenyl

ww – wet weight

4.1.7 Organochlorine pesticides

Table 4-8 presents a summary of detected organochlorine pesticides analyzed in fish and shellfish tissue samples, including the number of detections, the range of detected concentrations, and the range of RLs. Two dichlorodiphenyltrichloroethane (DDT) metabolites (4,4′-dichlorodiphenyldichloroethylene [DDE] and 4,4′-DDT) were detected in some of the fish and shellfish samples. 4,4′-DDE was detected in all tissue types except crab edible-meat and mussel samples, at concentrations ranging from 15 to 79 µg/kg ww. 4,4′-DDT was detected only in red rock crab hepatopancreas samples (all eight samples) at concentrations ranging from 23 to 80 µg/kg ww.

Table 4-8. Summary of detected organochlorine pesticides in fish and shellfish composite tissue samples and brown rockfish individual tissue samples

Species by Chemical	Detection Frequency	Detected Concentration (µg/kg ww)		Reporting Limits (µg/kg ww)
		Minimum	Maximum	
4,4'-DDE				
Mussel – whole body	0/11	nd	nd	9.1 – 9.8

Species by Chemical	Detection Frequency	Detected Concentration (µg/kg ww)		Reporting Limits (µg/kg ww)
		Minimum	Maximum	
Dungeness crab – edible meat	0/1	nd	nd	9.4
Dungeness crab – hepatopancreas	1/1	55 JN	55 JN	na
Red rock crab – edible meat	0/8	nd	nd	10
Red rock crab – hepatopancreas	2/8	15 JN	28 JN	10
Brown rockfish – whole body	10/13	15 JN	79 JN	9.5 – 9.6
English sole – fillet with skin	4/11	20 JN	28 JN	10
English sole – whole body	9/11	21 JN	46 JN	9.3 – 9.9
Shiner surfperch – whole body	2/8	18 JN	23 JN	9.5 – 9.9
4,4'-DDT				
Mussel – whole body	0/11	nd	nd	9.1 – 9.8
Dungeness crab – edible meat	0/1	nd	nd	9.4
Dungeness crab – hepatopancreas	0/1	nd	nd	130
Red rock crab – edible meat	0/8	nd	nd	10 – 18
Red rock crab – hepatopancreas	8/8	23 JN	80 JN	na
Brown rockfish – whole body	0/13	nd	nd	68 – 500
English sole – fillet with skin	0/11	nd	nd	10
English sole – whole body	0/11	nd	nd	9.2 – 160
Shiner surfperch – whole body	0/8	nd	nd	35 – 53
Total DDTs				
Mussel – whole body	0/11	nd	nd	na
Dungeness crab – edible meat	0/1	nd	nd	na
Dungeness crab – hepatopancreas	1/1	55 JN	55 JN	na
Red rock crab – edible meat	0/8	nd	nd	na
Red rock crab – hepatopancreas	8/8	23 JN	108 JN	na
Brown rockfish – whole body	10/13	15 JN	79 JN	na
English sole – fillet with skin	4/11	20 JN	28 JN	na
English sole – whole body	9/11	21 JN	46 JN	na
Shiner surfperch – whole body	2/8	18 JN	23 JN	na
Dieldrin				
Mussel – whole body	0/11	nd	nd	9.1 – 9.8
Dungeness crab – edible meat	0/1	nd	nd	9.4
Dungeness crab – hepatopancreas	1/1	47 JN	47 JN	na
Red rock crab – edible meat	0/8	nd	nd	10
Red rock crab – hepatopancreas	0/8	nd	nd	10
Brown rockfish – whole body	9/13	20 JN	53 JN	9.5 – 69
English sole – fillet with skin	0/11	nd	nd	10
English sole – whole body	0/11	nd	nd	9.2 – 9.9
Shiner surfperch – whole body	2/8	10 JN	12 JN	9.5 – 10
cis-Nonachlor[a]				
Mussel – whole body	0/11	nd	nd	9.1 – 9.8

Species by Chemical	Detection Frequency	Detected Concentration (µg/kg ww)		Reporting Limits (µg/kg ww)
		Minimum	Maximum	
Dungeness crab – edible meat	0/1	nd	nd	9.4
Dungeness crab – hepatopancreas	0/1	nd	nd	97
Red rock crab – edible meat	0/8	nd	nd	10 – 13
Red rock crab – hepatopancreas	8/8	14 JN	47 JN	na
Brown rockfish – whole body	0/13	nd	nd	9.5 – 10
English sole – fillet with skin	0/11	nd	nd	10
English sole – whole body	0/11	nd	nd	9.2 – 9.9
Shiner surfperch – whole body	0/8	nd	nd	22 – 33

Note: Other pesticides are not included in this table because they were not detected in any tissue types. This includes: 2,4'-DDD, 2,4'-DDE, 2,4'-DDT, 4,4'-DDD, aldrin, alpha-BHC, beta-BHC, gamma-BHC, delta-BHC, alpha-Chlordane, gamma-Chlordane, alpha-Endosulfan, beta-Endosulfan, Endosulfan sulfate, Endrin, Endrin aldehyde, Endrin ketone, Heptachlor, Heptachlor epoxide, Methoxychlor, Mirex, Oxychlordane, Toxaphene, and trans-Nonachlor.

[a] cis-Nonachlor is the only component of total chlordane that was detected, so detected concentrations of cis-nonachlor and total chlordane are equivalent.

DDE – dichlorodiphenyldichloroethylene

DDT – dichlorodiphenyltrichloroethane

JN – tentatively identified at an estimated concentration

na – not applicable

nd – not detected

ww – wet weight

Dieldrin and cis-nonachlor were the only other organochlorine pesticides detected in fish or shellfish tissue. Dieldrin was detected in 9 of the 13 brown rockfish samples, 2 of the 8 shiner surfperch samples, and in the single Dungeness crab hepatopancreas sample; concentrations ranged from 10 to 53 µg/kg ww. Cis-Nonachlor was detected only in red rock crab hepatopancreas samples (all eight samples) at concentrations ranging from 14 to 47 µg/kg ww. All detected pesticides were JN-qualified as tentatively identified because of probable analytical interferences with PCBs.

4.1.8 Lipids and total solids

Table 4-9 presents the lipid and total solids content in each fish and shellfish sample. Lipid contents in English sole fillet samples (0.915 to 2.45% ww) were generally lower than those in English sole whole-body samples (1.93 to 5.03% ww). Lipid contents in crab hepatopancreas samples (0.699 to 4.22% ww) were higher than those in edible meat samples (0.140 to 0.319% ww). Shiner surfperch lipid contents were generally higher than lipid contents in the other two fish species (4.44 to 5.66 % ww). Total solids concentrations ranged from 9.27 to 30.92%.

Table 4-9. Percent lipids and total solids in fish and shellfish composite tissue samples and brown rockfish individual samples

Species by Chemical	Detection Frequency	Measured Level (% ww)	
		Minimum	Maximum
Lipids			
Mussel – whole body	11/11	0.292	0.573
Coonstripe shrimp – whole body	1/1	0.825	0.825
Dungeness crab – edible meat	1/1	0.319	0.319
Dungeness crab – hepatopancreas	1/1	4.22	4.22
Red rock crab – edible meat	8/8	0.140	0.259
Red rock crab – hepatopancreas	8/8	0.699	3.80
Brown rockfish – whole body	13/13	2.42	4.41
English sole – fillet with skin	11/11	0.915	2.45
English sole – whole body	11/11	1.93	5.03
Shiner surfperch – whole body	8/8	4.44	5.66
Total Solids			
Mussel – whole body	11/11	9.27	12.21
Coonstripe shrimp – whole body	1/1	24.23	24.23
Dungeness crab – edible meat	1/1	19.88	19.88
Dungeness crab – hepatopancreas	1/1	18.62	18.62
Red rock crab – edible meat	8/8	17.99	19.36
Red rock crab – hepatopancreas	8/8	10.08	21.13
Brown rockfish – whole body	13/13	26.14	30.92
English sole – fillet with skin	11/11	19.49	21.66
English sole – whole body	11/11	19.78	24.15
Shiner surfperch – whole body	8/8	27.81	29.55

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 that were presented in Appendix D of the QAPP (Windward 2008). 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 analytes that required dilution, when available. The sample-specific RL is based on the lowest point of the calibration curve

associated with each analysis, whereas the MDL is 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 fish and shellfish tissue samples are compared with risk-based ACGs for all analytes in Table 4-10. Analytes with RLs greater than ACGs include inorganic arsenic, mercury, thallium, vanadium, 8 individual PAHs, BEHP, di-n-butyl phthalate, 25 other SVOCs, 6 individual Aroclors, and 16 pesticides. All of these chemicals also had one or more samples with MDLs exceeding ACGs with the exception of mercury, thallium, vanadium, and di-n-butyl phthalate.

The chemicals with RLs above ACGs were identified in Appendix D of the QAPP as having target MDLs and/or RLs above human health ACGs, with the exception of chrysene, dibenzofuran, BEHP, di-n-butyl phthalate, and nine other SVOCs. RLs for these additional chemicals were elevated because of analytical dilutions used by the laboratory. The samples were analyzed with a dilution because of the analytical interferences (i.e., lipid content) in the sample extracts.

Table 4-10. Number of RLs and MDLs above the ACGs for tissue samples

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of RLs for Non-Detected Results	No. of RLs > ACG	Range of MDLs for Non-Detected Results	No. of MDLs > ACG	Target RL	Target MDL	ACG[a]
Metals											
Arsenic (inorganic)	mg/kg ww	61	0.004 – 0.133	11	0.007 – 0.009	11	0.002 – 0.003	11	0.03	0.003	0.00054
Mercury	mg/kg ww	63	0.01 – 0.418	10	0.009 – 0.01	10	0.00094 – 0.00098	0	0.01	0.005	0.0084
Thallium	mg/kg ww	0	nd	73	0.004 – 0.008	17	0.0001 – 0.0002	0	0.02	0.011	0.0059
Vanadium	mg/kg ww	39	0.06 – 0.62	34	0.06 – 0.1	17	0.0077 – 0.016	0	0.2	0.034	0.084
PAHs											
Benzo(a)anthracene	µg/kg ww	0	nd	5	200 – 330	5	150 - 240	5	67	16	1.1
Benzo(a)pyrene	µg/kg ww	0	nd	5	200 – 330	5	110 - 190	5	67	17	0.11
Benzo(b)fluoranthene	µg/kg ww	0	nd	5	200 – 330	5	160 - 260	5	67	27	1.1
Benzo(k)fluoranthene	µg/kg ww	0	nd	5	200 – 330	5	140 - 230	5	67	15	11
Chrysene	µg/kg ww	0	nd	5	200 – 330	5	200 - 330	5	67	15	110
Dibenzo(a,h)anthracene	µg/kg ww	0	nd	5	200 – 330	5	130 - 220	5	67	14	0.11
Dibenzofuran	µg/kg ww	0	nd	5	200 – 330	5	82 - 140	5	67	15	84
Indeno(1,2,3–cd)pyrene	µg/kg ww	0	nd	5	200 – 330	5	120 - 200	5	67	12	1.1
Low-Level PAHs											
Benzo(a)anthracene	µg/kg ww	25	0.35 – 95	43	0.47—7.4	13	0.16 – 7.4	8	0.5	0.16	1.1
Benzo(a)pyrene	µg/kg ww	27	0.12 – 70	41	0.47–3.7	41	0.061 – 1.9	8	0.5	0.061	0.11
Benzo(b)fluoranthene	µg/kg ww	37	0.15 – 140	31	0.47–3.7	1	0.14 – 1.1	0	0.5	0.14	1.1
Dibenzo(a,h)anthracene	µg/kg ww	29	0.071 – 8.1	39	0.47–3.7	39	0.045 – 0.33	1	0.5	0.045	0.11
Indeno(1,2,3-cd)pyrene	µg/kg ww	36	0.1 – 37	32	0.48 – 3.7	1	0.1 – 0.73	0	0.5	0.10	1.1
Phthalates											

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of RLs for Non-Detected Results	No. of RLs > ACG	Range of MDLs for Non-Detected Results	No. of MDLs > ACG	Target RL	Target MDL	ACG[a]
BEHP	µg/kg ww	0	nd	60	200–1300	60	200 - 1,300	60	67	27	58
Low-level BEHP	µg/kg ww	0	nd	31	16 - 240	20	16 – 83	9	20	20	58
Di-n-butyl phthalate	µg/kg ww	0	nd	73	200 – 1,600	5	140 – 910	0	67	7.1	1,170 – 8,400
Other SVOCs											
1,2,4-Trichlorobenzene	µg/kg ww	0	nd	73	200 – 1,300	8	150 – 1,000	8	67	16	840
1,3-Dichlorobenzene	µg/kg ww	0	nd	73	200 – 1,300	43	110 – 760	8	67	16	250
1,4-Dichlorobenzene	µg/kg ww	1	4,800	72	200 – 1,300	73	120 – 820	72	67	14	34
2,4,6-Trichlorophenol	µg/kg ww	0	nd	73	990 – 6,700	73	530 – 3,600	73	330	65	73
2,4-Dichlorophenol	µg/kg ww	0	nd	73	990 – 6,700	73	590 – 4,000	73	330	120	250
2,4-Dinitrophenol	µg/kg ww	0	nd	73	2,000 – 13,000	73	1,100 – 7,200	73	670	110	170
2,4-Dinitrotoluene	µg/kg ww	0	nd	73	990 – 6,700	73	700 – 4,700	73	330	100	170
2,6-Dinitrotoluene	µg/kg ww	0	nd	73	990 – 6,700	73	900 – 6,000	73	330	110	84
2-Chlorophenol	µg/kg ww	0	nd	73	200 – 1,300	8	110 – 740	8	67	12	420
3,3'-Dichlorobenzidine	µg/kg ww	0	nd	70	990 – 6,700	70	160 – 1,100	70	330	210	1.8
4-Chloroaniline	µg/kg ww	0	nd	71	990 – 6,700	71	120 – 790	8	330	200	340
4-Methylphenol	µg/kg ww	0	nd	73	200 – 1,300	8	140 – 950	8	67	33	420
Aniline	µg/kg ww	0	nd	69	200 – 1,300	69	200 – 1,300	69	67	67	140
Bis(2-chloroethyl)ether	µg/kg ww	0	nd	73	200 – 1,300	73	150 – 980	73	67	15	0.73
Bis(2-chloroisopropyl)ether	µg/kg ww	0	nd	73	200 – 1,300	73	100 – 680	73	67	15	0.73
Carbazole	µg/kg ww	0	nd	73	200 – 1,300	73	140 – 970	73	67	7.7	40
Hexachlorobenzene	µg/kg ww	0	nd	73	4.6 – 330	73	1.9 – 250	73	10	4.2	0.5
Hexachlorobutadiene	µg/kg ww	0	nd	73	4.6 – 330	3	1.7 – 260	1	67	15	10
Hexachloroethane	µg/kg ww	0	nd	73	4.9 – 1,300	72	4.9 – 790	72	67	16	58

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of RLs for Non-Detected Results	No. of RLs > ACG	Range of MDLs for Non-Detected Results	No. of MDLs > ACG	Target RL	Target MDL	ACG[a]
Isophorone	µg/kg ww	0	nd	73	200 – 1,300	8	140 – 960	8	67	18	850
Nitrobenzene	µg/kg ww	0	nd	73	200 – 1,300	73	140 – 970	73	67	14	48
n-Nitrosodimethylamine	µg/kg ww	0	nd	73	990 – 6,700	73	490 – 3,300	73	330	86	0.016
n-Nitroso-di-n-propylamine	µg/kg ww	0	nd	73	990 – 6,700	73	540 – 3,700	73	330	67	0.12
n-Nitrosodiphenylamine	µg/kg ww	0	nd	73	200 – 1,300	73	100 – 700	43	67	16	160
PCP	µg/kg ww	0	nd	60	990– 6,700	60	710 - 4,800	60	330	170	6.7
Low-level pentachlorophenol	µg/kg ww	0	nd	31	3.9–11	3	2.4 – 7.1	1	5.0	5.0	6.7
PCBs											
Aroclor 1016	µg/kg ww	0	nd	73	9.3 – 100	50	2.4 – 66	46	20	2.9	12
Aroclor 1221	µg/kg ww	0	nd	73	19 – 200	73	2.6 – 190	73	20	2.9	0.4
Aroclor 1232	µg/kg ww	0	nd	73	9.3 – 100	73	2.3 – 79	73	20	2.9	0.4
Aroclor 1242	µg/kg ww	0	nd	73	9.3 – 100	73	2.2 – 74	73	20	3.9	0.4
Aroclor 1248	µg/kg ww	0	nd	73	9.3 – 120	73	0.51 – 120	73	20	3.9	0.4
Aroclor 1254	µg/kg ww	40	54 – 2400	33	19 – 1,600	33	19 – 1600	33	20	3.9	0.4
Pesticides											
4,4'-DDD	µg/kg ww	0	nd	72	9.1 – 20	72	6.6 – 15	72	20	15	3.4
4,4'-DDE	µg/kg ww	28	15 – 79	44	9.1 – 10	44	5.6 – 6.1	44	20	12	2.4
4,4'-DDT	µg/kg ww	8	23 – 80	64	9.1 – 500	64	6.1 – 13	64	20	13	2.4
Aldrin	µg/kg ww	0	nd	72	4.6 – 9.9	72	2.6 – 5.6	72	10	5.7	0.048
Dieldrin	µg/kg ww	12	10 – 53	60	9.1 – 69	60	5.5 – 6.0	60	20	12	0.05
alpha-BHC	µg/kg ww	0	nd	72	4.6 – 9.9	72	2.2 – 4.8	72	10	4.8	0.13
beta-BHC	µg/kg ww	0	nd	72	4.6 – 9.9	72	1.8 – 3.9	72	10	3.9	0.45
gamma-BHC	µg/kg ww	0	nd	72	4.6 – 9.9	72	2.3 – 5.0	72	10	5.0	0.62
Total chlordane	µg/kg ww	8	14 – 47	64	9.1 – 97	64	9.1 – 97	64	100	60	2.3

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of RLs for Non-Detected Results	No. of RLs > ACG	Range of MDLs for Non-Detected Results	No. of MDLs > ACG	Target RL	Target MDL	ACG[a]
alpha-Endosulfan	µg/kg ww	0	nd	72	4.6 – 9.9	24	2.7 – 5.9	24	20	11	0.62 – 500
beta-Endosulfan	µg/kg ww	0	nd	71	9.1 – 74	24	4.8 – 10	24	20	11	0.62 – 500
Endrin	µg/kg ww	0	nd	71	9.1 - 99	24	6.6 – 14	24	20	15	1.2 – 25
Heptachlor	µg/kg ww	0	nd	72	4.6 – 9.9	72	2.6 – 5.6	72	10	5.6	0.18
Heptachlor epoxide	µg/kg ww	0	nd	72	4.6 – 43	72	2.6 – 5.6	72	10	5.1	0.089
Methoxychlor	µg/kg ww	0	nd	72	46 – 99	18	29 – 62	18	10	63	15 – 420
Toxaphene	µg/kg ww	0	nd	72	460 – 990	72	460 – 990	72	1,000	1,000	0.73

[a] The ACG for crab edible meat tissue samples was used to evaluate the RLs and MDLs of crab hepatopancreas samples. Human ingestion rate of hepatopancreas is not available, but is expected to be lower than the ingestion rate of crab edible meat. Therefore, ACGs for hepatopancreas would be higher, so the chemicals with ACGs lower than the RL and MDL would not be affected.

ACG – analytical concentration goal

ARI – Analytical Resources, Inc.

BEHP – bis(2-ethylhexyl) phthalate

BHC – benzene hexachloride

DDE – dichlorodiphenyldichloroethylene

DDT – dichlorodiphenyltrichloroethane

MDL – maximum detection limit

nd – not detected

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

PCP – pentachlorophenol

RL – reporting limit

SVOC – semivolatile organic compound

tbd – to be determined

ww – wet weight

4.3 DATA VALIDATION RESULTS

Independent data validation was performed by EcoChem on all results 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, 2002b). EcoChem conducted full-level data validation on at least 20% of the results. All sample results that were not selected for full validation underwent a summary validation. The percent of samples submitted for full validation for each analysis is consistent with QAPP 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 Tissue Samples	Analyses
Brooks Rand Labs	0902011	full/summary [a]	71	total and inorganic arsenic
ARI	OF34	summary	8	total metals including mercury, butyltins, SVOCs, pesticides, lipids, total solids
ARI	OF35	full	8	total metals including mercury, butyltins, SVOCs, pesticides, lipids, total solids
ARI	OF36	summary	11	total metals including mercury, butyltins, SVOCs, pesticides, lipids, total solids
ARI	OF41	summary	13	total metals including mercury, butyltins, SVOCs, pesticides, lipids, total solids
ARI	OF42	summary	11	total metals including mercury, butyltins, SVOCs, pesticides, lipids, total solids
ARI	OF43	summary	11	total metals including mercury, butyltins, SVOCs, pesticides, lipids, total solids
ARI	OG18	full	8	total metals including mercury, butyltins, SVOCs, pesticides, lipids, total solids
ARI	OG20	summary	2	total metals including mercury, butyltins, SVOCs, pesticides, lipids, total solids
ARI	PJ35	full	13	low-level BEHP and PCP
ARI	PJ64	summary	15	low-level BEHP and PCP
ARI	PJ68	summary	3	low-level BEHP and PCP
CAS	K0900129	full	8	PCB Aroclors
CAS	K0900132	summary	11	PCB Aroclors
CAS	K0900134	summary	11	PCB Aroclors
CAS	K0900136	summary	13	PCB Aroclors
CAS	K0900137	summary	8	PCB Aroclors
CAS	K0900138	full	11	PCB Aroclors
CAS	K0900139	summary	2	PCB Aroclors

Laboratory	SDG	Validation Level	Number of Tissue Samples	Analyses
CAS	K0900140	summary	8	PCB Aroclors
CAS	K0900873	summary	1	PCB Aroclors
CAS	K0907127	summary	12	low-level PAHs
CAS	K0907551	full/summary[a]	45	low-level PAHs
CAS	K0907575	summary	11	low-level PAHs

[a] Full-level data validation was conducted on at least 20% of results in this SDG. Summary-level data validation was conducted on the remaining results in this SDG.

ARI – Analytical Resources, Inc.

BEHP – bis(2-ethylhexyl) phthalate

CAS – Columbia Analytical Services, Inc.

PCB – polychlorinated biphenyl

PCP – pentachlorophenol

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 (CCV), internal standard, surrogate, laboratory control sample (LCS), laboratory control sample duplicate (LCSD), matrix spike (MS), matrix spike duplicate (MSD), and interference check sample 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. Seventeen results for ten chemicals were rejected as a consequence of data validation. Rejected results will not be used for any purpose. Based on the information reviewed, the overall data quality was 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 D.

- Seventeen results were rejected during data validation because of extremely low MS/MSD recoveries (less than 10%). Rejected results include four results for aniline; three results for 3,3'-dichlorobenzidine; two results each for 4-chloroaniline and 4-nitroaniline; and one result each for monobutyltin, beta-endosulfan, endrin, endrin aldehyde, 3-nitroaniline, and benzoic acid.
- Results for various chemicals were qualified as estimated (J- or UJ-qualified) because MS/MSD, LCS/LCSD, CCV, surrogate, or contract-required detection limit standard recoveries or relative percent differences (RPDs) were outside of control limits. Results qualified as estimated include the following: all non-rejected results for monobutyltin (71) and aniline (69); 35 results for nickel; 34 results for silver; 13 results each for 3,3'-dichlorobenzidine and 2,4-dimethylphenol; 12 results for antimony; 9 results for chromium; 6 results for selenium; 5 results for TBT; 3 results for dibutyltin and BEHP; 2 results each for

benzoic acid, PCP, and 4-chloroaniline; and 1 result each for inorganic arsenic, 3-nitroaniline, n-nitrosodimethylamine, and 20 individual PAHs.

- Results for several individual PAHs and BEHP were re-qualified as non-detect because of method blank contamination, including the results for naphthalene in 52 samples; 2-methylnapthalene in 23 samples; BEHP in 19 samples; 1-methylnapthalene in 18 samples; perylene and phenanthrene in 12 samples each; benzo(k)fluoranthene in 4 samples; benzo(b)fluoranthene and benzo(g,h,i)perylene in 3 samples each; fluroanthene and indeno(1,2,3-cd)pyrene in 2 samples each; and benzo(a)anthracene, benzo(a)pyrene, dibenzo(a,h)anthracene, pyrene and diethylhexyl phthalate in 1 sample each. These chemicals are commonly found in laboratory method blank samples during low-level analysis.
- The RPDs between the results of dual-column analyses for Aroclor 1260 in 17 samples, 4,4'-DDE in 11 samples, dieldrin in 6 samples, and Aroclor 1254 in 2 samples were greater than the control limit of ±40% and less than ±60%. These results were J-qualified to indicate estimated concentrations. The dual-column RPDs for Aroclor 1260 in nine samples, dieldrin in three samples, 4,4'-DDE in two samples, and Aroclor 1254 in one sample were greater than ±60% and were requalified as estimated with tentative identification (JN). The reported result was selected from the analytical column with the higher of the two values. Samples were not reanalyzed for elevated dual-column RPDs if all other QC criteria were met, but results were flagged as estimated by the laboratory.
- In consultation with the EPA, all detected pesticides were JN-qualified as tentatively identified because of probable analytical interferences with PCBs.
- Non-detect results for 28 chemicals were Y-qualified by ARI or Ui-qualified by CAS as non-detected at elevated RLs because chromatographic interference in the sample prevented adequate resolution of the compound at the standard RLs. Qualified results include 188 results for 6 PCB Aroclors; 92 results for 7 PAHs; 87 results for 10 pesticides; 13 results each for butylbenzyl phthalate, BEHP, and di-n-butylphthalate; and 1 result each for dibutyltin and hexachlorobutadiene.

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