Lower Duwamish Waterway Group

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

QUALITY ASSURANCE PROJECT PLAN: FISH AND CRAB TISSUE COLLECTION AND CHEMICAL ANALYSES: APPENDICES A-E

FINAL

For submittal to

The US Environmental Protection Agency
Region 10
Seattle, WA

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

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Acronyms

ACRONYM	Definition
2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
ACG	analytical concentration goal
BW	body weight
CPR	cardiopulmonary resuscitation
FC	field coordinator
HSM	Project Health and Safety Manager
HSO	Field Health and Safety Officer
HSP	health and safety plan
OSHA	Occupational Safety and Health Administration
PFD	personal flotation device
PM	Project Manager
PPE	personal protective equipment
DFC	daily food consumption rate
dw	dry weight
Ecology	Washington State Department of Ecology
EPA	US Environmental Protection Agency
ERA	ecological risk assessment
HHRA	human health risk assessment
LDW	Lower Duwamish Waterway
LOAEL	lowest-observed-adverse-effect level
LOEC	lowest-observed-effect concentration
MDL	method detection limit
NOAEL	no-observed-adverse-effect level
NOEC	no-observed-effect concentration
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
QAPP	Quality Assurance Project Plan
RBC	risk-based concentration
SVOC	semivolatile organic compound
TEQ	toxic equivalent
TBT	tributyltin
Windward	Windward Environmental LLC
ww	wet weight

APPENDIX A: HEALTH AND SAFETY PLAN

Title and Approval Page:
LDW Tissue Sampling Health and Safety Plan

By their signature, the undersigned certify that this Health and Safety Plan (HSP) is approved and that it will be used to govern health and safety aspects of fieldwork described in the Quality Assurance Project Plan to which it is attached.

Name Project Manager	Date
Name Corporate Health and Safety Manager	Date
Name Field Coordinator/Health and Safety Officer	Date

A.1.0 Introduction

This site-specific health and safety plan (HSP) describes safe working practices for conducting field activities at potentially hazardous sites and for handling potentially hazardous materials/waste products. This HSP covers elements as specified in 29CFR1910§120. The procedures and guidelines contained herein are based on generally recognized health and safety practices. Any changes or revisions to this plan will be made by a written amendment that will become a permanent part of this plan. The goal of the HSP is to establish procedures for safe working practices for all field personnel and visitors.

This HSP addresses all activities associated with collection and handling of biological specimens from the Lower Duwamish Waterway (LDW) for preparation of tissue samples for chemical analyses. During site work, this HSP will be implemented by the Field Coordinator (FC), who is also the designated site Health and Safety Officer (HSO), in cooperation with the Windward Corporate Health and Safety Manager (HSM) and the Windward Project Manager (PM).

All personnel involved in fieldwork on this project are required to comply with this HSP. The contents of this HSP reflect anticipation of the types of activities to be performed, knowledge of the physical characteristics of the site, and consideration of preliminary chemical data from previous investigations at the site. The HSP may be revised based on new information and/or changed conditions during site activities. Revisions will be documented in the project records.

A.2.0 Site Description and Project Scope

A.2.1 Site Description

The sampling area is in the LDW (see Figure 3-1 in the QAPP). The QAPP to which this HSP is attached provides complete details of the sampling program. The following section summarizes the types of work that will be performed during field activities.

A.2.2 Scope of Work

Specific tasks to be performed are as follows:

- collection of biological specimens from a boat using a high-rise-trawl
- collection of biological specimens from a boat using shrimp and crab traps
- collection of biological specimens in shallow, nearshore water using a beach seine
- sample handling, processing, and shipping

Additional details on the sampling design and sampling methods are provided in Section 3.0.

A.3.0 Health and Safety Personnel

Key health and safety personnel and their responsibilities are described below. These individuals are responsible for the implementation of this HSP and will be responsible for informing all individuals assigned to work on the site, or visit the site, of the contents of this plan and ensuring that each person signs the Site Safety Plan Acknowledgment Form. By signing the Safety Plan Acknowledgment Form, individuals recognize the site health and safety hazards, known or suspected, and will adhere to the protocols required to minimize exposure to such hazards.

Project Manager: The PM has overall responsibility for the successful outcome of the project. The PM will ensure that adequate resources and budget are provided for the health and safety staff to carry out their responsibilities during fieldwork. The PM, in consultation with the HSM, makes final decisions concerning implementation of the HSP.

Field Coordinator/Health and Safety Officer: Because of the limited scope and duration of fieldwork, the Field Coordinator (FC) and Health and Safety Officer (HSO) will be the same person. The FC/HSO will direct field sampling activities, coordinate the technical components of the field program with health and safety components, and ensure that work is performed according to the QAPP.

The FC/HSO will implement this HSP at the work location and will be responsible for all health and safety activities and the delegation of duties to a health and safety technician in the field, if appropriate. The FC/HSO also has stop-work authority, to be used if there is an imminent safety hazard or potentially dangerous situation. The FC/HSO or his designee will be present during sampling and operations.

Corporate Health and Safety Manager: The HSM has overall responsibility for preparation, approval, and revisions of this HSP. The HSM will not necessarily be present during fieldwork, but will be readily available, if required, for consultation regarding health and safety issues during fieldwork.

Field Crew: All field crew members must be familiar with and comply with the information in this HSP. They also have the responsibility to report any potentially unsafe or hazardous conditions to the FC/HSO immediately.

A.4.0 Hazard Evaluation and Control Measures

This section covers potential physical and chemical hazards that may be associated with the proposed project activities, and presents control measures for addressing these hazards. The activity hazard analysis, Section A.4.3, lists the potential hazards

associated with each site activity and the recommended site control to be used to minimize each potential hazard.

Confined space entry will not be necessary for this project. Therefore, hazards associated with this activity are not discussed in this HSP.

A.4.1 PHYSICAL HAZARDS

For this project, it is anticipated that physical hazards will present a greater risk of injury than chemical hazards. Physical hazards are identified and discussed below.

A.4.1.1 Slips, trips, and falls

As with all field work, caution should be exercised to prevent slips on slick surfaces. In particular, sampling from a boat or other floating platform requires careful attention to minimize the risk of falling down or of falling overboard. The same care should be used in rainy conditions or on the shoreline where slick rocks are found. Slips can be minimized by wearing boots with good tread, made of material that does not become overly slippery when wet.

Trips are always a hazard on the uneven deck of a boat, in a cluttered work area, or in the intertidal zone where uneven substrate is common. Personnel will keep work areas as free as possible from items that interfere with walking.

Falls may be avoided by working as far from exposed edges as possible, by erecting railings, and by using fall protection when working on elevated platforms. For this project, no work is anticipated that would present a fall hazard.

A.4.1.2 Sampling equipment deployment

A high-rise trawl, shrimp and crab traps, and beach seine will be used to collect tissue samples as described in Section 3.2 of the QAPP. Appropriate seining protocols will be used in the deployment and hauling of the seine to ensure safety of the field personnel. Before sampling activities begin, there will be a training session for all field personnel for the equipment that will be onboard the sampling vessel.

A.4.1.3 Falling overboard

Some of the sampling activities will be conducted from a boat. As with any work from a floating platform, there is a chance of falling overboard. Personal flotation devices (PFDs) will be worn while working on the boat.

A.4.1.4 Manual lifting

Equipment and samples must be lifted and carried. Back strain can result if lifting is done improperly. During any manual handling tasks, personnel should lift with the load supported by their legs and not their backs. For heavy loads, an adequate number of people will be used, or if possible, a mechanical lifting/handling device will be used.

A.4.1.5 Heat stress, hypothermia, or frostbite

Sampling operations and conditions that might result in the occurrence of heat stress, hypothermia, or frostbite are not anticipated. The sampling will occur during the time of year when extreme weather conditions are not expected to occur.

A.4.1.6 Weather

In general, field team members will be equipped for the normal range of weather conditions. The FC/HSO will be aware of current weather conditions, and of the potential for those conditions to pose a hazard to the field crew. Some conditions that might force work stoppage are electrical storms, high winds, or high waves resulting from winds.

A.4.1.7 Vessel traffic

Because of the high volumes of vessel and barge traffic on the LDW, precautions and safe boating practices will be implemented to ensure that the field boat does not interrupt vessel traffic. As practical, the field boat will stay out of the navigation channel.

A.4.2 CHEMICAL HAZARDS

Previous investigations have shown that some chemicals are present at higher-than-background concentrations in the sampling area. For the purposes of discussing potential exposure to chemicals in sediments, the chemicals of concern are metals, tributyltin (TBT), petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs).

A.4.2.1 Exposure routes

Potential routes of chemical exposure include inhalation, dermal contact, and ingestion. Exposure will be minimized by using safe work practices and by wearing the appropriate personal protective equipment (PPE). Further discussion of PPE requirements is presented in Section A.7.

Inhalation —Inhalation is not expected to be an important route of exposure.

Dermal exposure — Dermal exposure to hazardous substances associated with sediments, surface water, or equipment decontamination will be controlled by the use of PPE and by adherence to detailed sampling and decontamination procedures.

Ingestion — Incidental ingestion of sediment or surface water is not considered a major route of exposure for this project. Accidental ingestion of surface water is possible. However, careful handling of equipment and containers onboard the boat should prevent the occurrence of water splashing or spilling during sample collection and handling activities.

A.4.2.2 Description of chemical hazards

Metals and tributyltin — Exposure to metals may occur via ingestion or skin contact. As mentioned above, neither is likely as an exposure route. Metal fumes or metal-contaminated dust will not be encountered during field and sample handling activities. Large amounts of sediment would need to be ingested for any detrimental effects to occur. Momentary skin contact allows little, if any, opportunity for passage of any of the metals into the body. Field procedures require immediate washing of sediments from exposed skin.

Petroleum hydrocarbons and PAHs — Exposure to petroleum hydrocarbons and PAHs may occur via ingestion or skin contact. The most important human health exposure pathway for this group of chemicals, inhalation, is not expected to occur at this site. Animal studies have also shown that PAHs can cause harmful effects on the skin, body fluids, and ability to fight disease after both short- and long-term exposure, but these effects have not been seen in people. Some PAHs may reasonably be expected to be carcinogens. Large amounts of sediment would need to be ingested for any detrimental effects to occur. Momentary skin contact allows little, if any, opportunity for passage of any of the compounds into the body. Field procedures require immediate washing of sediments from exposed skin.

Polychlorinated biphenyls — Prolonged skin contact with PCBs may cause acne-like symptoms known as chloracne. Irritation to eyes, nose, and throat may also occur. Acute and chronic exposure can damage the liver, and cause symptoms of edema, jaundice, anorexia, nausea, abdominal pains, and fatigue. PCBs are a suspected human carcinogen. Skin absorption may substantially contribute to the uptake of PCBs. Large amounts of sediment would need to be ingested for any detrimental effects to occur. Momentary skin contact allows little, if any, opportunity for passage of any of the compounds into the body. Field procedures require immediate washing of sediments from exposed skin.

A.4.3 ACTIVITY HAZARD ANALYSIS

The activity hazard analysis summarizes the field activities to be performed during the project, outlines the hazards associated with each activity, and presents controls that can reduce or eliminate the risk of the hazard occurring.

Table A-1 presents the activity hazard analysis for the following activities:

- Tissue sampling from boat
- Tissue sampling from shore

Table A-1. Activity hazard analysis

ACTIVITY	HAZARD	CONTROL
Sampling from a boat and shore	Falling overboard	Use care in boarding/departing from vessel. Deploy and recover the net or traps from the back deck of the boat. Wear PFD.
	Skin contact with contaminated sediments or liquids	Wear modified Level D PPE.
	Back strain	Use appropriate lifting technique when deploying and retrieving pots, or seek help.

A.5.0 Work Zones and Shipboard Access Control

During sampling and sample handling activities, work zones will be established to identify where sample collection and processing are actively occurring. The intent of the zone is to limit the migration of sample material out of the zone and to restrict access to active work areas by defining work zone boundaries.

A.5.1 WORK ZONE

The work zone will encompass the area where sample collection and handling activities are performed. Work zones will be identified for each sampling gear type. The FC/HSO will delineate the work zone as a particular area on-board the collection vessels (for high-rise trawl and traps) or on the beach (for beach seining). Only persons with appropriate training, PPE, and authorization from the FC/HSO will be allowed to enter the work zone while work is in progress.

A.5.2 DECONTAMINATION STATION

A decontamination station will be set up, and personnel will clean soiled boots or PPE prior to leaving the work zone. The station will have the buckets, brushes, soapy water, rinse water, or wipes necessary to clean boots, PPE, or other equipment leaving the work zones. Plastic bags will be provided for expendable and disposable materials. If the location does not allow the establishment of a decontamination station, the FC/HSO will provide alternatives to prevent the spread of contamination.

Decontamination of the boat will also be completed at the end of each work day. Cockpit and crew areas will be rinsed down with water to minimize accumulation of sediment.

A.5.3 ACCESS CONTROL

Security and control of access to the boat will be the responsibility of the FC/HSO and boat captain. Boat access will be granted only to necessary project personnel and authorized visitors. Any security or access control problems will be reported to the client or appropriate authorities.

A.6.0 Safe Work Practices

Following common sense rules will minimize the risk of exposure or accidents at a work site. These general safety rules will be followed on site:

- Do not climb over or under obstacles of questionable stability.
- Do not eat, drink, smoke, or perform other hand-to-mouth transfers in the work zone.
- Work only in well-lighted spaces.
- Never enter a confined space without the proper training, permits, and equipment.
- Make eye contact with equipment operators when moving within the range of their equipment.
- Be aware of the movements of shipboard equipment when not in the operator's range of vision.
- Get immediate first aid for all cuts, scratches, abrasions, or other minor injuries.
- Use the established sampling and decontamination procedures.
- Always use the buddy system.
- Be alert to your own and other workers' physical condition.
- Report all accidents, no matter how minor, to the FC/HSO.
- Do not do anything dangerous or unwise even if ordered by a supervisor.

A.7.0 Personal Protective Equipment and Safety Equipment

Appropriate PPE will be worn as protection against potential hazards. In addition, a PFD will be required when working onboard the boat. Prior to donning PPE, the field crew will inspect their PPE for any defects that might render the equipment ineffective.

Fieldwork will be conducted in Level D or modified Level D PPE, as discussed below in Sections A.7.1 and A.7.2. Situations requiring PPE beyond modified Level D are not anticipated. Should the FC/HSO determine that PPE beyond modified Level D is necessary, the HSM will be notified and an alternative selected.

New personnel or visitors will be informed of PPE requirements during their initial site briefing (see Section A3.0).

A.7.1 LEVEL D PERSONAL PROTECTIVE EQUIPMENT

Workers performing general activities in which skin contact with contaminated materials is unlikely will wear Level D PPE. Level D PPE includes the following:

- cotton overalls or lab coats
- chemical-resistant steel-toed boots
- chemical-resistant gloves
- safety glasses

A.7.2 MODIFIED LEVEL D PERSONAL PROTECTIVE EQUIPMENT

Workers performing activities where skin contact with contaminated materials is possible and in which inhalation risks are not expected will be required to wear an impermeable outer suit. The type of outerwear will be chosen according to the types of chemical contaminants that might be encountered. Modified Level D PPE includes the following:

- impermeable outer garb such as rain gear
- chemical-resistant steel-toed boots
- chemical-resistant outer gloves

A.7.3 SAFETY EQUIPMENT

In addition to PPE that will be worn by shipboard personnel, basic emergency and first aid equipment will also be provided. Equipment for the field team will include:

- a copy of this HSP
- first aid kit adequate for the number of personnel
- emergency eyewash

The FC/HSO will ensure that the safety equipment is onboard. Equipment will be checked daily to ensure its readiness for use.

A.8.0 Monitoring Procedures for Site Activities

A monitoring program that addresses the potential site hazards will be maintained. For this project, air, dust, and noise monitoring will not be necessary. No volatile organic compounds have been identified among the expected contaminants, the sampled media will be wet and will not pose a dust hazard, and none of the equipment emits high-amplitude (>85 dBA) sound. For this project, the monitoring program will consist of all workers monitoring themselves and their co-workers for signs that might indicate physical stress or illness.

All personnel will be instructed to look for and inform each other of any deleterious changes in their physical or mental condition during the performance of all field activities. Examples of such changes are as follows:

- headaches
- dizziness
- nausea
- symptoms of heat stress
- blurred vision
- cramps
- irritation of eyes, skin, or respiratory system
- changes in complexion or skin color
- changes in apparent motor coordination
- increased frequency of minor mistakes
- excessive salivation or changes in papillary response
- changes in speech ability or speech pattern
- shivering
- blue lips or fingernails

If any of these conditions develop, work will be halted immediately and the affected person(s) evaluated. If further assistance is needed, personnel at the local hospital will be notified, and an ambulance will be summoned if the condition is thought to be serious. If the condition is the direct result of sample collection or handling activities, procedures will be modified to address the problem.

A.9.0 Decontamination

Decontamination is necessary to prevent the migration of contaminants from the work zone(s) into the surrounding environment and to minimize the risk of exposure of personnel to contaminated materials that might adhere to PPE. The following sections discuss personnel and equipment decontamination. The following supplies will be available to perform decontamination activities:

- wash buckets
- rinse buckets
- long-handled scrub brushes
- clean water sprayers

- paper towels
- plastic garbage bags
- Alconox® or similar decontamination solution

A.9.1 MINIMIZATION OF CONTAMINATION

The first step in addressing contamination is to prevent or minimize exposure to existing contaminated materials and the spread of those materials. During field activities, the FC/HSO will enforce the following measures:

Personnel:

- Do not walk through areas of obvious or known contamination.
- Do not handle, touch, or smell contaminated materials directly.
- Make sure PPE has no cuts or tears prior to use.
- Fasten all closures on outer clothing, covering with tape if necessary.
- Protect and cover any skin injuries.
- Stay upwind of airborne dusts and vapors.
- Do not eat, drink, chew tobacco, or smoke in the work zones.

Sampling equipment and boat:

- Place clean equipment on a plastic sheet or aluminum foil to avoid direct contact with contaminated media.
- Keep contaminated equipment and tools separate from clean equipment and tools.
- Clean boots before entering the boat.

A.9.2 PERSONNEL DECONTAMINATION

The FC/HSO will ensure that all site personnel are familiar with personnel decontamination procedures. Personnel will perform the following decontamination procedures, as appropriate, before eating lunch, taking a break, or before leaving the work location:

1. If outer suit is heavily soiled, rinse it off.
2. Wash and rinse outer gloves and boots with water.
3. Remove outer gloves; inspect and discard if damaged.
4. Wash hands if taking a break.
5. Don necessary PPE before returning to work.

Dispose of soiled, expendable PPE before leaving for the day.

A.9.3 SAMPLING EQUIPMENT DECONTAMINATION

Sampling equipment will be decontaminated as described in Section 3.3.2 of the QAPP. In summary, to minimize sample contamination, the following practices will be followed:

- Caught fish will only be placed on clean surfaces, such as aluminum foil (dull side touching the fish).
- Ice chests will be scrubbed with Alconox® detergent and rinsed with deionized water prior to any sampling activities.
- Samples will be placed in resealable, waterproof plastic bags to avoid contamination from melting ice.
- Sampling equipment will be free from contaminants such as oils, grease, and fuels.
- All utensils or equipment used directly in handling fish (e.g., such as measuring boards) will be scrubbed with Alconox® detergent and rinsed with deionized water, and stored in aluminum foil until use.

A.10.0 Disposal of Contaminated Materials

Contaminated materials that may be generated during field activities include PPE and excess sample material. These contaminated materials will be disposed of as an integral part of the project.

A.10.1 PERSONAL PROTECTIVE EQUIPMENT

Gross surface contamination will be removed from PPE. All disposable sampling materials and PPE, such as disposable coveralls, gloves, and paper towels used in sample processing, will be placed in heavyweight garbage bags. Filled garbage bags will be placed in a normal refuse container for disposal as solid waste.

A.10.2 EXCESS SAMPLE MATERIALS

At each sampling location, excess or unwanted specimens collected for tissue samples will be returned to the water.

A.11.0 Training Requirements

Individuals performing work at locations where potentially hazardous materials and conditions may be encountered must meet specific training requirements. It is not anticipated that hazardous concentrations of contaminants will be encountered in sampled material, so training will consist of site-specific instruction for all personnel and oversight of inexperienced personnel by an experienced person for one working day. The following sections describe the training requirements for this fieldwork.

A.11.1 PROJECT-SPECIFIC TRAINING

In addition to HAZWOPER training, as described in Section 2.5 of the QAPP, field personnel will undergo training specifically for this project. All personnel and visitors must read this HSP and be familiar with its contents before beginning work or providing oversight. They must acknowledge reading the HSP by signing the HSP review form contained in Attachment 1. The form will be kept in the project files.

The boat captain and FC/HSO will also be required to have the US Coast Guard Auxiliary Boating Safely certification. The boat captain or a designee will provide project-specific training prior to the first day of fieldwork and whenever new workers arrive. Field personnel will not be allowed to begin work until project-specific training is completed and documented by the FC/HSO. Training will address the HSP and all health and safety issues and procedures pertinent to field operations. Training will include, but not be limited to, the following topics:

- activities with the potential for chemical exposure
- activities that pose physical hazards, and actions to control the hazard
- ship access control and procedures
- use and limitations of PPE
- decontamination procedures
- emergency procedures
- use and hazards of sampling equipment
- location of emergency equipment on the vessel
- vessel safety practices
- vessel evacuation and emergency procedures

A.11.2 DAILY SAFETY BRIEFINGS

The FC/HSO or a designee and the boat captain will present safety briefings before the start of each day's activities. These safety briefings will outline the activities expected for the day, update work practices and hazards, address any specific concerns associated with the work location, and review emergency procedures and routes. The FC/HSO or designee will document safety briefings in the logbook.

A.11.3 FIRST AID AND CPR

At least one member of the field team must have first-aid and cardiopulmonary resuscitation (CPR) training. Documentation of which individuals possess first-aid and CPR training will be kept in the project health and safety files.

A.12.0 Medical Surveillance

A medical surveillance program conforming to the provisions of 29 CFR 1910§120(f) is not necessary for field team members because they do not meet any of the following four criteria outlined in the regulations for implementation of a medical surveillance program:

- Employees who are or may be exposed to hazardous substances or health hazards at or above permissible exposure levels for 30 days or more per year (1910.120(f)(2)(I).
- Employees who must wear a respirator for 30 days or more per year (1910.120(f)(2)(ii)).
- Employees who are injured or become ill as a result of possible overexposures involving hazardous substances or health hazards from an emergency response or hazardous waste operation (1910.120(f)(2)(iii)).
- Employees who are members of HAZMAT teams (1910.120(f)(2)(iv)).

As described in Section A.8, employees will monitor themselves and each other for any deleterious changes in their physical or mental condition during the performance of all field activities.

A.13.0 Reporting and Record Keeping

Each member of the field crew will sign the HSP review form (see Attachment 1). If necessary, accident/incident report forms and OSHA Form 200s will be completed by the FC/HSO.

The FC/HSO or a designee will maintain a health and safety field logbook that records health- and safety-related details of the project. Alternatively, entries may be made in the field logbook, in which case a separate health and safety logbook will not be required. The logbook must be bound and the pages must be numbered consecutively. Entries will be made with indelible blue ink. At a minimum, each day's entries must include the following information:

- project name or location
- names of all personnel onboard
- weather conditions
- type of fieldwork being performed

The person maintaining the entries will initial and date the bottom of each completed page. Blank space at the bottom of an incompletely filled page will be lined out. Each day's entries will begin on the first blank page after the previous workday's entries.

A.14.0 Emergency Response Plan

As a result of the hazards onboard and the conditions under which operations will be conducted, the potential exists for an emergency situation to occur. Emergencies may include personal injury, exposure to hazardous substances, fire, explosion, or release of toxic or non-toxic substances (spills). OSHA regulations require that an emergency response plan be available for use onboard to guide actions in emergency situations.

Onshore organizations will be relied upon to provide response in emergency situations. The local fire department and ambulance service can provide timely response. Field personnel will be responsible for identifying an emergency situation, providing first aid if applicable, notifying the appropriate personnel or agency, and evacuating any hazardous area. Shipboard personnel will attempt to control only very minor hazards that could present an emergency situation, such as a small fire, and will otherwise rely on outside emergency response resources.

The following sections identify the onboard individual(s) who should be notified in case of emergency, provide a list of emergency telephone numbers, offer guidance for particular types of emergencies, and provide directions and a map for getting from any sampling location to a hospital.

A.14.1 Pre-emergency Preparation

Before the start of field activities, the FC/HSO will ensure that preparation has been made in anticipation of emergencies. Preparatory actions include the following:

- Meeting with the FC/HSO and equipment handlers concerning the emergency procedures in the event that a person is injured.
- A training session given by the FC/HSO informing all field personnel of emergency procedures, locations of emergency equipment and their use, and proper evacuation procedures.
- A training session given by senior staff operating field equipment, to apprise field personnel of operating procedures and specific risks associated with that equipment.
- Ensuring that field personnel are aware of the existence of the emergency response plan in the HSP and ensuring that a copy of the HSP accompanies the field team.

A.14.2 Project Emergency Coordinator

The FC/HSO will serve as the Project Emergency Coordinator in the event of an emergency. He will designate his replacement for times when he is not onboard or is not serving as the Project Emergency Coordinator. The designation will be noted in the logbook. The Project Emergency Coordinator will be notified immediately when an emergency is recognized. The Project Emergency Coordinator will be responsible

for evaluating the emergency situation, notifying the appropriate emergency response units, coordinating access with those units, and directing interim actions onboard before the arrival of emergency response units. The Project Emergency Coordinator will notify the HSM and the Windward PM as soon as possible after initiating an emergency response action. The Windward PM will have responsibility for notifying the client.

A.14.3 EMERGENCY RESPONSE CONTACTS

All onboard personnel must know whom to notify in the event of an emergency situation, even though the FC/HSO has primary responsibility for notification. Table A-2 lists the names and phone numbers for emergency response services and individuals.

Table A-2. Emergency response contacts

CONTACT	TELEPHONE NUMBER
Emergency Numbers	
Ambulance	911
Police	911
Fire	911
Harborview Medical Center	(206) 323-3074
Emergency Responders	
U.S. Coast Guard Emergency General information	 (206) 286-5400 (206) 442-5295 UHF Channel 16
National Response Center	(800) 424-8802
US Environmental Protection Agency	1-800-424-8802
Washington State Department of Ecology – Northwest Region Spill Response (24-hour emergency line)	(206) 649-7000
Emergency Contacts	
Windward Project Manager	
Kathy Godtfredsen	(206) 577-1283
Windward Corporate Health and Safety Manager	
Tad Deshler	(206) 577-1285
Field Coordinator/ Field Health and Safety Officer	Site cellular telephone:
Bob Complita	(206) 954-1780

A.14.4 RECOGNITION OF EMERGENCY SITUATIONS

Emergency situations will generally be recognizable by observation. An injury or illness will be considered an emergency if it requires treatment by a medical professional and cannot be treated with simple first-aid techniques.

A.14.5 DECONTAMINATION

In the case of evacuation, decontamination procedures will be performed only if doing so does not further jeopardize the welfare of site workers. If an injured individual is also heavily contaminated and must be transported by emergency vehicle, the emergency response team will be told of the type of contamination. To the extent possible, contaminated PPE will be removed, but only if doing so does not exacerbate the injury. Plastic sheeting will be used to reduce the potential for spreading contamination to the inside of the emergency vehicle.

A.14.6 FIRE

Field personnel will attempt to control only small fires, should they occur. If an explosion appears likely, personnel will follow evacuation procedures specified during the training session. If a fire cannot be controlled with a fire extinguisher on board that is part of the required safety equipment, personnel will either withdraw from the vicinity of the fire or evacuate the boat as specified in the training session.

A.14.7 PERSONAL INJURY

In the event of serious personal injury, including unconsciousness, possibility of broken bones, severe bleeding or blood loss, burns, shock, or trauma, the first responder will immediately do the following:

- Administer first aid, if qualified.
- If not qualified, seek out an individual who is qualified to administer first aid, if time and conditions permit.
- Notify the Project Emergency Coordinator of the incident, the name of the injured individual(s), the location, and the nature of the injury.

The Project Emergency Coordinator will immediately do the following:

- Notify the boat captain and the appropriate emergency response organization.
- Assist the injured individual(s).
- Follow the emergency procedures for retrieving or disposing equipment reviewed in the training session and leave the site en route to the predetermined land-based emergency pickup.
- Designate someone to accompany the injured individual to the hospital.
- If a life-threatening emergency occurs, i.e., injury where death is imminent without immediate treatment, the FC/HSO or boat captain will call 911 and arrange to meet the Medic One unit at the nearest accessible dock. Otherwise, for emergency injuries that are not life-threatening (i.e., broken bones, minor lacerations, etc.) the Project Emergency Coordinator will follow

the procedures outlined above and proceed to the Harbor Island Marina or to an alternative location of his choice if that would be more expedient.

- Notify the HSM and the Project Manager.

If the Project Emergency Coordinator determines that emergency response is not necessary, he or she may direct someone to decontaminate and transport the individual by vehicle to the nearest hospital. Directions showing the route to the hospital are in Section A.14.11.

If a worker leaves the boat to seek medical attention, another worker should accompany them to the hospital. When in doubt about the severity of an injury or exposure, always seek medical attention as a conservative approach, and notify the Project Emergency Coordinator.

The Project Emergency Coordinator will have responsibility for completing all accident/incident field reports, OSHA Form 200s, and other required follow-up forms.

A.14.8 OVERT PERSONAL EXPOSURE OR INJURY

If an overt exposure to toxic materials occurs, the first responder to the victim will initiate actions to address the situation. The following actions should be taken, depending on the type of exposure.

A.14.8.1 Skin contact

- Wash/rinse the affected area thoroughly with copious amounts of soap and water.
- If eye contact has occurred, eyes should be rinsed for at least 15 minutes using the eyewash that is part of the emergency equipment onboard.
- After initial response actions have been taken, seek appropriate medical attention.

A.14.8.2 Inhalation

- Move victim to fresh air.
- Seek appropriate medical attention.

A.14.8.3 Ingestion

- Seek appropriate medical attention.

A.14.8.4 Puncture wound or laceration

- Seek appropriate medical attention.

A.14.9 SPILLS AND SPILL CONTAINMENT

No bulk chemicals or other materials subject to spillage are expected to be used during this project. Accordingly, no spill containment procedure is required for this project.

A.14.10 BOATING HAZARDS

Emergency responses to boating hazards are described in Table A-3.

Table A-3. Potential boat emergency hazards and responses

POTENTIAL EMERGENCY HAZARD	RESPONSE
Fire or explosion	If manageable, attempt to put out a small fire with a fire extinguisher. Otherwise, call the Coast Guard or 911 and evacuate the area (by life rafts, rescue boat, or swimming) and meet at a designated area. The field manager will take roll call to make sure everyone evacuated safely. Emergency meeting places will be determined in the field during the daily safety briefings.
Medical emergency/ personal injury	At least one person with current first aid-CPR training will be onboard the vessel at all times. This person will attempt to assess the nature and critical path of the injury, call 911 immediately, and apply CPR if necessary. Stop work and wait for medical personnel to arrive. Fill out a site accident report.
Person overboard	Immediately throw the person in the water a life ring. Have one person keep an eye on the person and shout the distance (boat lengths) and direction (o'clock) of the person from the vessel. Stop work and use the vessel to retrieve the person in the water.
Sinking vessel	Call the Coast Guard immediately. If possible, wait for a rescue boat to arrive to evacuate vessel personnel. See fire/explosion section for emergency evacuation procedures. The field manager will take a roll call to make sure everyone is present.
Hydraulic oil spill or leak	If the leak/spill is small, immediately apply absorbent pads to control the leak and continue work. If the leak/spill is uncontainable, stop work, call 911 immediately, and wait for assistance. The vessel operator will assess the personal safety hazard associated with the leak/spill and begin evacuation procedures if necessary.
Lack of visibility	If the navigation visibility or personal safety is compromised because of smoke, fog, or other unanticipated hazards, stop work immediately. The vessel operator and field manager will assess the hazard and, if necessary, send out periodic horn blasts to mark vessel location to other vessels potentially in the area, move to a secure location (i.e., berth), and wait for the visibility to clear.
Loss of power	Stop work and call Coast Guard for assistance. Vessel personnel should watch for potential collision hazards and notify vessel operator if hazards exist. Secure vessel to a berth, dock, or mooring as soon as possible.
Collision	Stop work and call Coast Guard for assistance. Field manager and vessel operator will assess damage and potential hazards. If necessary, vessel will be evacuated and secured until repairs can be made.

A.14.11 EMERGENCY ROUTE TO THE HOSPITAL

The name, address, and telephone number of the hospital that will be used to provide medical care is as follows:

Harborview Medical Center
325 - 9th Ave.
Seattle, WA
(206) 323-3074

Directions from the vicinity of LDW to Harborview Medical Center are as follows:

- Dock the vessel at the 1st Ave S boat launch.
- Drive east on S River Street.
- Turn left on Occidental Ave S.
- Turn left on E Marginal Way S.
- Turn right on S Michigan Street.
- Look for entrance ramps to I-5 Northbound.
- Head north on I-5.
- Take the James Street exit.
- Head east on James Street to 9th Avenue.
- Turn right on 9th Avenue.
- Emergency entrance will be two blocks south on the right.

Attachment A1. Field Team Health and Safety Plan Review

I have read a copy of the Health and Safety Plan, which covers field activities that will be conducted to investigate potentially contaminated areas in the LDW. I understand the health and safety requirements of the project, which are detailed in this Health and Safety Plan.

Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date

APPENDIX B. FORMS

This appendix contains the following forms that will be used, as necessary, during this study:

- Target fish and crab species collection form
- Protocol modification form
- Corrective action form
- Specimen label
- Non-target species tally form
- Composite formation form

FORM B-1. FISH AND CRAB TISSUE COLLECTION FORM

Project Name:	**LDW RI fish and crab chemistry**	**Project #:**	**04-08-06-22**
Date:		**Sampling area:**	
Retrieval Time:		**Start coordinates**	**X:**
Collection method/Effort #:			**Y:**
Weather:		**End coordinates**	**X:**
Sampler:			**Y:**
Comments:			

SPECIMEN ID #	SPECIES	LENGTH (nearest mm)	WEIGHT (nearest 0.1 g)	COMMENTS

FORM B-2. PROTOCOL MODIFICATION FORM

Project Name and Number: _____

Material to be Sampled: _____

Measurement Parameter: _____

Standard Procedure for Field Collection & Laboratory Analysis (cite reference):

Reason for Change in Field Procedure or Analysis Variation: _____

Variation from Field or Analytical Procedure: _____

Special Equipment, Materials or Personnel Required: _____

Initiator's Name: _____ Date: _____

Project Officer: _____ Date: _____

QA Officer: _____ Date: _____

FORM B-3. CORRECTIVE ACTION FORM

Project Name and Number: _____

Sample Dates Involved: _____

Measurement Parameter: _____

Acceptable Data Range: _____

Problem Areas Requiring Corrective Action: _____

Measures Required to Correct Problem: _____

Means of Detecting Problems and Verifying Correction: _____

Initiator's Name: _____ Date: _____

Project Officer: _____ Date: _____

QA Officer: _____ Date: _____

FORM B-4. SPECIMEN LABEL

Windward Environmental LLC 200 West Mercer Street, Suite 401, Seattle, WA 98119 Tel: (206) 378-1364 Fax: (206) 217-0089	
Project #: 04-08-06-22	Sampler:
Sampling date:	Sampling time:
Specimen ID #:	
Comments:	

FORM B-5. NON-TARGET SPECIES TALLY FORM

Project Name:	**LDW RI fish and crab chemistry**	**Project #:**	**04-08-06-22**
Date:		**Sampling area:**	
Retrieval Time:		**Start coordinates**	**X:**
Collection method/Effort #:			**Y:**
Weather:		**End coordinates**	**X:**
Sampler:			**Y:**
Comments:			

SPECIES	#	LENGTH (nearest mm)	WEIGHT (nearest 0.5 g)	COMMENTS

FORM B-6. COMPOSITE FORMATION FORM

Project Name:	**LDW RI fish and crab chemistry**		**Project #:** **04-08-06-22**
Date composited:		**Species:**	**Subarea:**
Composite ID:		**Sample type:** (circle one) whole fish/crab fillet hepatopancreas	
Composite volume:		**Number of individuals:**	

SPECIMEN ID	LENGTH (mm)	WEIGHT (g)	SEX	DATE COLLECTED	SAMPLING METHOD
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

APPENDIX C. STANDARD OPERATING PROCEDURE FOR TISSUE PREPARATION

Standard operating procedures for tissue dissection and homogenization are in separate PDF files. These are confidential AXYS documents and are not to be distributed outside the recipients of this QAPP. The tissue homogenization QAPP also includes sections on analyzing plant tissue, pulps, sediment and soil, and sludges. These sections do not pertain to this QAPP. The following sections of the homogenization SOP are pertinent to this project: 1) initial instructions, 2) record keeping, and 3) homogenizing animal tissue. Additionally, Table 2, uses of homogenization equipment (at the end of the SOP), lists the appropriate equipment for tissues of different mass.

APPENDIX D. ANALYTICAL CONCENTRATION GOALS

D.1.0 Introduction

This appendix addresses the following question:

> Are standard analytical methods proposed for the chemical analyses of fish and crab tissue sufficiently sensitive to meet the needs of the Phase 2 ecological and human health risk assessments?

To answer this question, standard method detection limits (MDLs) were compared to analytical concentration goals (ACGs). ACGs are defined for ecological receptors as the concentration of a chemical in tissue of a receptor or in its food associated with no effects,[1] and defined for human health as the concentration of a chemical in food that has been identified as having an acceptable risk level (e.g., excess cancer risk no higher than 10^{-6}). ACGs have not been developed by the US Environmental Protection Agency (EPA) Region 10 for the receptors of interest. Therefore, these concentrations were determined by reviewing the toxicological literature for fish and wildlife, and by reviewing human health guidance documents. Although information from the toxicological literature is used in this document, the objective of this memo is not to establish the toxicity reference values (TRVs) to be used for the Phase 2 risk assessments. The TRVs to be used in those assessments will be determined during Phase 2, in consultation with EPA and the Washington State Department of Ecology (Ecology).

To determine ACGs for this quality assurance project plan (QAPP),[2] risk-based concentrations (RBCs) were identified or derived for each receptor species that either: 1) consumes fish or crabs (i.e., piscivorous fish, birds, mammals, and humans), or 2) will be assessed for risk based on chemical concentrations in its own tissue (i.e., fish and crabs) (Table D-1). In this appendix, the RBCs for receptor species that consume fish or crab are identified as dietary RBCs, and the RBCs for receptor species that are based on chemicals in their own tissue are identified as critical tissue residue RBCs. The dietary RBCs are expressed as chemical concentrations in tissue of fish or crabs that are food for receptors, and the critical tissue residue RBCs are expressed as concentrations in tissue of the receptor. The ACG for a given tissue is equal to the lowest dietary or critical tissue residue RBC for any receptor ingesting or representing that tissue for each chemical. So, for instance, if both humans and river otters consume

[1] The lowest concentration associated with adverse effects was used if data were not available for a concentration associated with no effects.

[2] ACGs associated with market basket benthic invertebrate tissues, clams, and gastropods are presented in an appendix to the benthic invertebrate QAPP (Windward 2004a).

crabs, the ACG for cadmium in crabs is set by the RBC of the receptor most sensitive to cadmium (the lower of the two RBCs).

The remainder of this appendix is organized as follows:

- Section D.2.0 – RBC derivation methods for each receptor
- Section D.3.0 – Comparison of ACGs to MDLs
- Section D.4.0 – Tissue mass required for analysis
- Section D.5.0 – Tables
- Section D.6.0 – References

Tables D-1 through D-12 summarize RBCs for all receptors for each chemical, list studies selected for each receptor for the calculation of RBCs, compare ACGs and MDLs, and summarize tissue mass requirements to meet MDLs. These tables are located in Section D.5.0.

D.2.0 Risk-based Concentrations

For this QAPP, RBCs are tissue concentrations associated with an acceptable risk level as derived from the toxicity literature or human health guidance documents. In this appendix, RBCs are derived for receptors and exposure pathways that are associated with either fish or crab tissue samples, as shown in Table D-1.

The following sections describe how RBCs were derived for each receptor. The RBCs for each of the receptors are summarized in Table D-2; this table includes RBCs for chemicals of interest presented in Table D-3 although RBCs are also presented for the other chemicals when this information was readily available. The list of chemicals in Table D-3 was presented in a draft technical memorandum to EPA and Ecology (Windward 2003a). This memorandum identified specific chemicals for analysis in tissue using a set of decision points based on the following: 1) detection in at least 5% of Lower Duwamish Waterway (LDW) Phase 1 surface sediment samples, 2) identification as a bioaccumulative chemical by EPA (2000), and 3) detection in tissue collected from the LDW.

For some chemicals in Table D-3, no relevant toxicity data were available for certain receptors. RBCs were not derived for individual dioxin/furan congeners. Analysis of these congeners in tissue will be conducted if the results of the urban background analysis in sediments indicate that quantitative risk characterization is needed (see Section 3.1.8.1 in the Phase 2 work plan, Windward 2004b). If analyzed, the concentrations of individual dioxin/furan congeners would be included in the calculated toxic equivalent (TEQ) for comparison to toxicity data for 2,3,7,8-tetrachlorodibenzo(p)dioxin (2,3,7,8-TCDD).

D.2.1 CRITICAL TISSUE RESIDUE RBC DERIVATION FOR THE PROTECTION OF CRABS

RBCs derived for the protection of crabs are expressed as chemical concentrations in crab tissue. Critical tissue residue RBCs derived for the protection of crabs will be considered in the determination of ACGs for crab tissue samples.

To derive critical tissue residue RBCs for the protection of crabs for this QAPP, toxicity data were reviewed for effects of chemicals on crabs and other decapod crustaceans. Toxicity data for other decapod crustaceans were included because few toxicity studies were available for crabs. No-observed-effect concentrations (NOECs) and lowest-observed-effect concentrations (LOECs) in crab or decapod crustacean tissue were identified based on the effect endpoints of growth, reproduction, and survival.[3]

The NOECs and LOECs presented in the literature are expressed as chemical concentrations in test species tissue in units of mg/kg wet weight (ww). Table D-2 summarizes RBCs for crabs, including both NOECs and LOECs, if available. The NOEC-based RBC is the most relevant concentration; LOEC-based RBCs are presented in case the NOEC-based RBC is less than the MDL. Table D-4 presents summary information for the studies selected to derive RBCs in crab tissue, including the endpoint, test species, exposure pathway, and reference for each NOEC and LOEC shown. The following sections describe the literature search process and the derivation of RBCs for crabs.

D.2.1.1 Literature search

Studies relating tissue concentrations in crabs to adverse effects were identified from a search of the following sources:

- Environmental Residue Effects Database (ERED 2003)
- Jarvinen and Ankley (1999), a compilation of tissue residue NOECs and LOECs

Toxicity studies were reviewed for methods, relevance, and interpretation to ensure that NOECs and LOECs were derived appropriately. Toxicity studies were rejected if there was no control group for comparison to treated groups, or if crabs were exposed to more than one chemical (except for PCB and DDT mixtures). Toxicity studies that analyzed chemicals in muscle or claw tissue rather than whole-body tissue were used if whole-body data were not available.

RBCs were derived from the crab study with the lowest LOEC, and the crab study with the highest NOEC that was lower than the LOEC for the same endpoint. If no crab studies were available, the RBCs were derived from studies with other decapod crustaceans. For some chemicals, only a NOEC or a LOEC for the same endpoint were available, but not both. In addition, for some chemicals, no relevant toxicity data were available and RBCs could not be calculated.

[3] These assessment endpoints will be used in the Phase 2 risk assessments for crabs, as discussed in the Phase 2 work plan (Windward 2004b).

D.2.1.2 RBC Derivation

RBCs for crabs are equal to the LOECs and NOECs from the literature toxicity studies. All RBCs are reported on a wet weight basis in crab tissue. If only dry weight concentrations were reported in individual literature toxicity studies, these concentrations were converted to a wet weight basis using assumptions regarding moisture content of crabs, as noted in Table D-4.

D.2.2 CRITICAL TISSUE RESIDUE RBC DERIVATION FOR THE PROTECTION OF FISH

Critical tissue residue RBCs derived for the protection of fish are expressed as chemical concentrations in the whole-body tissue of the receptor fish species (i.e., sculpin and English sole[4]). Critical tissue residue RBCs were derived in this section for those chemicals that were evaluated using a critical tissue residue approach in the Phase 1 ecological risk assessment (ERA) (i.e., mercury, organochlorine pesticides, tributyltin [TBT], PCBs, and certain semivolatile organic compounds [SVOCs]). In addition, a critical tissue residue RBC is derived for 2,3,7,8-TCDD because this chemical may be evaluated in the Phase 2 ERA. These chemicals are evaluated using a critical tissue residue approach because they are not metabolized or otherwise regulated by fish, and are thus more likely to bioaccumulate in tissue. A dietary approach will be used in the Phase 2 ERA for chemicals that are metabolized or otherwise regulated by fish (i.e., PAHs and metals other than mercury); dietary RBCs for the protection of piscivorous fish are discussed in Section D.2.3.[5] Critical tissue residue RBCs derived for the protection of fish will be considered in the determination of ACGs for sculpin and English sole tissue samples.

To derive critical tissue residue RBCs for the protection of fish, toxicity data were reviewed for effects of mercury, organochlorine pesticides, TBT, PCBs, and certain SVOCs on fish species; NOECs and LOECs in fish tissue were identified. Effects endpoints considered were growth, reproduction, and survival.[6]

The NOECs and LOECs presented in the literature are expressed as chemical concentrations in whole-body fish tissue in units of mg/kg ww. Table D-2 summarizes RBCs for fish, including both NOECs and LOECs, if available. The NOEC-based RBC is the most relevant concentration; LOEC-based RBCs are presented in case the NOEC-based RBC is less than the MDL. Table D-5 presents summary information for the studies selected to represent RBCs in fish tissue, including the endpoint, test species, exposure pathway, and reference for each NOEC and LOEC shown. The following sections describe the literature search process and the derivation of RBCs for the protection of fish.

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[4] Juvenile chinook salmon are also an ROC for the Phase 2 ERA, but were addressed in a separate QAPP (Windward 2003c).

[5] Dietary RBCs for non-piscivorous fish (e.g., benthivorous fish) were presented in Appendix C of the benthic invertebrate QAPP (Windward 2004a).

[6] These assessment endpoints will be used in the Phase 2 risk assessments for fish, as discussed in the Phase 2 work plan (Windward 2004b).

D.2.2.1 Literature search

Studies relating whole-body tissue concentrations in fish to adverse effects in fish were identified from a search of the following sources:

- ECOTOX database (2003)
- Scientific literature searches using BIOSIS and Science Direct
- Environmental Residue Effects Database (ERED 2003)

Toxicity studies were reviewed for methods, relevance, and interpretation to ensure that NOECs and LOECs were derived appropriately. Toxicity studies were rejected if there was no control group for comparison to treated groups, or if fish were exposed to more than one chemical (except for PCB and DDT mixtures). For dioxins and dioxin-like PCB congeners, an RBC was derived for 2,3,7,8-TCDD.[7] Studies reporting effects associated with egg tissue concentrations were not used because of the uncertainty associated with comparing concentrations in fish eggs to concentrations in adult and juvenile whole-body fish. Bioaccumulation studies in which tissue concentrations were associated with no toxic effect were also not used. Methods in these studies are not designed to measure toxicity and are not useful for application as threshold toxicity values. Studies in which exposure was via dietary ingestion or water exposure were preferred when available. Studies that included exposure through injection or oral gavage were not preferred for RBC derivation because these exposure routes cannot be directly related to environmental exposure of fish.

RBCs were derived from the study with the lowest LOEC, and the study with the highest NOEC that was lower than the LOEC for the same endpoint. For some chemicals, only a NOEC or a LOEC for the same endpoint were available, but not both. In addition, for some chemicals, no relevant toxicity data were available and RBCs could not be calculated.

D.2.2.2 RBC Derivation

RBCs for the protection of fish are equal to the LOECs and NOECs from the toxicological literature (Table D-5). All RBCs are reported on a wet weight basis in fish.

D.2.3 Dietary RBC Derivation for the Protection of Piscivorous Fish

Dietary RBCs derived for the protection of piscivorous fish[8] are expressed as chemical concentrations in their prey for those chemicals evaluated using a dietary approach in the Phase 1 ERA (i.e., PAHs and metals, except mercury). RBCs for other chemicals to be evaluated for fish in the Phase 2 ERA, such as PCBs, mercury, DDT, and TBT, are

[7] In Phase 2, the TRV derived for 2,3,7,8-TCDD may be compared to TEQ exposure concentrations (calculated for dioxins and dioxin-like PCB congeners, based on World Health Organization [WHO] derived toxic equivalency factors [TEFs] for fish).

[8] Although sculpin are representing piscivorous fish in the Phase 2 ERA, sculpin also consume benthic invertebrates and thus serve more precisely as a general representative of a higher-trophic-level fish.

determined using a critical tissue residue approach (Section D.2.2). Dietary RBCs are expressed as concentrations in fish prey for these chemicals because they are metabolized or otherwise regulated by fish. RBCs derived for prey fish tissue for the protection of piscivorous fish will be considered in the determination of ACGs for English sole[9] and perch tissue samples described in this QAPP.

RBCs for piscivorous fish represent chemical concentrations in fish prey independent of prey type. For example, Pacific staghorn sculpin consume both benthic invertebrates and fish. Because it is not known what percentages of the sculpin's diet are represented by benthic invertebrates and fish, or what the chemical concentrations would be in those different prey items, the dietary RBC for the protection of fish is assumed to be the same whether it is applied to fish tissue or to benthic invertebrate tissue. Thus, a single dietary RBC will be applicable for any type of prey tissue in the diet (i.e., English sole, perch, or benthic invertebrates), and is relevant in setting the ACG for all tissue types consumed by fish.

To derive RBCs for the protection of fish for this QAPP, toxicity data were reviewed for effects of PAHs and metals (other than mercury) on fish species, and NOECs and LOECs in fish food were identified. Effects endpoints considered were growth, reproduction, and survival.[10]

The NOECs and LOECs derived from the literature are expressed as chemical concentrations in fish prey items in units of mg/kg ww. Table D-2 summarizes RBCs for fish, based on both NOECs and LOECs, if available. The NOEC-based RBC is the most relevant concentration; LOEC-based RBCs are presented in case the NOEC-based RBC is less than the MDL. Table D-6 presents summary information for the studies selected to derive RBCs in fish prey items. The summary information in Table D-6 includes the endpoint, test species, exposure pathway, and reference for each NOEC and LOEC shown. The following sections describe the literature search process and the derivation of RBCs for the protection of piscivorous fish.

D.2.3.1 Literature search

Studies relating chemical concentrations in fish food to adverse effects in fish were identified from a search of the following sources:

- ECOTOX (2003)
- scientific literature searched using BIOSIS and Science Direct

Toxicity studies were reviewed for methods, relevance, and interpretation to ensure that NOECs and LOECs were derived appropriately. Toxicity studies were rejected if there was no control group for comparison to treated groups, or if fish were exposed to more than one chemical (except for PAH mixtures). Studies where fish were fed live

[9] Sculpin could ingest young-of-the-year English sole, but not adults, which would be too large.

[10] These assessment endpoints will be used in the Phase 2 risk assessments for fish, as discussed in the Phase 2 work plan (Windward 2004b).

prey that was exposed to a chemical were preferred over studies where fish were fed a prepared diet dosed with the chemical of interest, because the natural assimilation of metals or PAHs through live prey is more ecologically relevant and comparable to the exposure of the selected fish receptors in the LDW. Concentrations of the dosed chemical were measured in both the live prey and the prepared food studies to determine the NOEC and LOEC.

RBCs were derived from the study with the lowest LOEC, and the study with the highest NOEC that was lower than the LOEC for the same endpoint. For some chemicals, either a NOEC or a LOEC for the same endpoint were available, but not both. In addition, for some chemicals, no relevant toxicity data were available and RBCs could not be calculated.

D.2.3.2 RBC Derivation

RBCs for the protection of piscivorous fish are equal to LOECs and NOECs derived from the toxicological literature (Table D-6). All RBCs are reported on a wet weight basis in fish food. If only dry weight concentrations were reported in individual literature toxicity studies, these concentrations were converted to a wet weight basis using assumptions regarding moisture content of specific prey for each study, as noted in Table D-6.

D.2.4 Dietary RBC Derivation for the Protection of Birds and Mammals

RBCs for the protection of piscivorous birds and mammals are expressed as chemical concentrations in the tissues of their prey. RBCs derived for the protection of osprey, great blue heron, river otter, and harbor seal will be considered in the determination of ACGs for the fish tissue samples, and RBCs derived for the protection of river otter will be considered in the determination of ACGs for crab tissue samples. Other prey items for river otter (e.g., clams) will have RBCs presented in the benthic invertebrate tissue QAPP (Windward 2004a).

RBCs for wildlife represent chemical concentrations in their prey independent of prey type. For example, river otters may consume fish, crabs, and clams. Because it is not known what percentage of the river otter diet is represented by different types of prey, or what the chemical concentrations would be in the different prey items, the RBC for river otter is assumed to be the same whether it is applied to fish tissue or other prey tissue types.

Toxicity data identified for bird and mammal species were no-observed-adverse-effect levels (NOAELs), which are the highest dietary doses at which no adverse effects were observed, and lowest-observed-adverse-effect levels (LOAELs), which are the lowest dietary doses at which adverse effects were observed. Effects endpoints included growth, reproduction, and survival.[11]

[11] These assessment endpoints will be used in the Phase 2 risk assessments for wildlife, as discussed in the Phase 2 work plan (Windward 2004b).

The NOAELs and LOAELs derived from the literature are expressed as dietary doses in mg/kg body weight (bw)/day. These dietary doses were converted to RBCs in prey tissue in mg/kg ww using the receptor's food ingestion rate and body weight (as described in Section D.2.4.2). Table D-2 summarizes wildlife RBCs, including both NOAELs and LOAELs, if available. The NOAEL-based RBC is the most relevant concentration; LOAEL-based RBCs are presented in case the NOAEL-based RBC is less than the MDL. Tables D-7 and D-8 present summary information for the studies selected to derive RBCs in bird and mammal prey items, respectively, including the endpoint, test species, exposure pathway, and reference for each NOAEL and LOAEL shown. The following sections describe the literature search process and the conversion of dietary doses to dietary RBCs.

D.2.4.1 Literature search

Studies relating dietary concentrations to adverse effects in wildlife were identified from searches of the following electronic databases: ECOTOX, BIOSIS, TOXNET, and IRIS. In addition, reviews of the following summary reports were used to identify original studies for wildlife toxicity data:

- Agency for Toxic Substances and Disease Registry (ATSDR)
- US Fish and Wildlife Service Contaminant Review series (Eisler 2002)
- Oak Ridge National Laboratory database (Sample et al. 1996)

Toxicity studies were reviewed for methods, relevance, and interpretation to ensure that RBCs were derived appropriately. Studies were excluded if there was no control group for comparison to treated groups, or if test species were exposed to more than one chemical. Exceptions were made for certain mixtures of related chemicals such as a mixture of DDT and its metabolites, a mixture of PCB Aroclors, or a mixture of PAHs if PAH-specific data are not available. These requirements eliminated most field studies from consideration in the development of RBCs, because field studies generally lack suitable controls, and organisms are typically exposed to a mixture of different types of chemicals in the field.

The LOAELs and NOAELs for RBC derivation were selected as follows: 1) the selected LOAEL was the lowest LOAEL from any study using any of the specified endpoints (i.e., growth, reproduction, survival), and 2) the selected NOAEL was the highest NOAEL that was lower than the selected LOAEL for the same endpoint as the selected LOAEL. Studies were not used for RBC derivation if the following concerns warranted the consideration of other studies:

- The exposure duration was not chronic[12] or was not conducted during a sensitive life stage (i.e., reproduction, gestation, or development).

[12] Chronic exposure is defined as more than 10 weeks for avian receptors and more than one year for mammals (Sample et al. 1996).

- The effect endpoint was egg productivity in a domestic species, such as chickens or Japanese quail. These species are bred to have unnaturally high egg-laying rates, so toxic threshold effects on egg production in these species are not comparable to similar effects in non-domestic avian receptors because of differences in reproductive physiology.
- Exposure was through gavage, oral intubation, or injection rather than through the diet. These routes of exposure are not directly related to environmental exposures to the bird or mammal. In addition, studies with drinking water exposures may overestimate dietary risk because gastrointestinal absorption may be higher for chemicals ingested via drinking water than through diet (Sample et al. 1996). However, studies with doses administered via injection, oral intubation, gavage, or drinking water were used for RBC selection if no other studies were available.
- Results were not statistically evaluated to identify significant differences from control values.
- Endpoints were not related to growth, reproduction, or survival.

For some chemicals, either a NOAEL or a LOAEL for the same endpoint were available, but not both. In addition, for some chemicals, no relevant toxicity data were available.

D.2.4.2 RBC Derivation

The NOAELs and LOAELs derived from toxicity studies were expressed as daily dietary doses normalized for body weight. To convert these doses to a tissue concentration in ingested food, the following equation was used:

$$C_F = (Dose \times BW)/DFC$$

where:

C_F = concentration in food (mg/kg ww)
Dose = NOAEL or LOAEL (mg/kg bw/day)
BW = body weight (kg)
DFC = daily food consumption rate (kg ww/day)

If the NOAEL or LOAEL was based on a reproductive endpoint, the C_F was calculated using the female BW and DFC. If the NOAEL or LOAEL was based on growth or survival, C_F was calculated using the male and female average for BW and DFC. The BW and DFC values used in deriving RBCs are presented in Table D-9. The lowest calculated C_F for each receptor was chosen as the RBC, as summarized in Table D-2. RBCs are presented for both NOAELs and LOAELs, where available.

D.2.5 Dietary RBC Derivation for the Protection of Humans

RBCs for the protection of humans that might ingest crabs and fish are expressed as chemical concentrations in crab and fish tissue. Human health guidance documents

were reviewed for RBCs for human health. EPA Region 10 has not developed RBCs in food organisms for the protection of human health. EPA Region 9 has developed RBCs for the protection of human health for exposures to soil and water (EPA 1996), but not for consumption of fish tissue. The Model Toxics Control Act (MTCA, a Washington State statute), which contains human health risk-based cleanup levels for several media, considers uptake into tissue (i.e., fish) from surface water but does not directly provide a human health RBC for tissue. EPA Region 3 (EPA 2001) provides an approach for the development of RBCs for fish tissue, which, after modification for site-specific exposure factors, was used to derive RBCs for fish and crab tissue in this appendix.

RBCs can be calculated for chemicals with either carcinogenic or non-carcinogenic endpoints; some chemicals have both types of endpoints. The RBC equations are shown below:

$$\text{RBC(carcinogenic)} = \frac{TR \times BW \times AT_c}{EF \times ED \times IR \times CF \times CSF}$$

$$\text{RBC(noncarcinogenic)} = \frac{THQ \times RfD \times BW \times AT_n}{EF \times ED \times IR}$$

where:

TR = target risk (1×10^{-6})
BW = body weight (79 kg, from Phase 1 HHRA)
AT_c = averaging time, carcinogenic (25,550 days, from Phase 1 HHRA)
EF = exposure frequency (365 days/yr, from Phase 1 HHRA)
ED = exposure duration (55 years, from Phase 1 HHRA)
IR = ingestion rate (see text below)
CF = conversion factor (unitless, factor of 0.001 needed to convert kg to g)
CSF = cancer slope factor (kg-day/mg, chemical-specific)
THQ = target hazard quotient (0.1, EPA 1996)
RfD = reference dose (mg/kg-day, chemical-specific)
AT_n = averaging time, non-carcinogenic (20,075 days, from Phase 1 HHRA)

In the Phase 1 HHRA, a consumption rate of 84 g/day was used to represent the combined consumption rate for all seafood species. For the purposes of this appendix, EPA has requested that a seafood consumption rate of 98 g/day be used to calculate RBCs for the protection of human consumers. This rate is the 95th percentile rate for the combined consumption of pelagic fish, benthic fish, and shellfish[13] as estimated in the Tulalip Tribes fish consumption survey (Toy et al. 1996). The consumption rate for any one of these three food groups is lower than 98 g/day. For example, the consumption rate used in the Phase 1 human health risk assessment (HHRA) for

[13] Shellfish included clams, cockles, mussels, oysters, shrimp, crabs, moon snails, scallops, squid, sea urchin, and sea cucumber.

benthic fish was 15 g/day. To provide a range of RBCs,[14] two consumption rates were used for each tissue type. The lower rate is equal to the consumption rate used in the Phase 1 HHRA (i.e., 45 g/day for crabs, 16 g/day for pelagic fish, and 15 g/day for benthic fish). The rate of 98 g/day for combined food groups is used as the upper rate for each food group. This range of rates is used to ensure that ACGs calculated in this appendix are conservative and to reflect the uncertainty in the seafood consumption rates. The Phase 2 HHRA will use a shellfish consumption rate that include clams, crabs, and mussels, but this rate has not been established, pending the release of additional EPA Region 10 guidance for evaluating tribal fish and shellfish consumption.

D.3.0 Comparison of ACGs to MDLs

ACGs were determined for each tissue type that will be analyzed as part of the fish and crab tissue QAPP (i.e., sculpin, English sole, perch, and crab).[15] The ACG for each tissue type was determined by selecting the lowest RBC for each chemical for each receptor associated with that tissue type, as presented in Table D-2. In addition to the range of human health RBCs presented in Table D-2, which are based on the lowest consumption rate for any single seafood group (benthic fish: 15 g/day) and the highest consumption rate (total seafood: 98 g/day). Table D-10 summarizes the RBCs used in deriving the ACG for each tissue type. These ACGs for sculpin, English sole, perch, and crab tissue samples are compared with MDLs in Table D-11.

As shown in Table D-11, the MDLs for 87 chemicals were less than the ACGs, and thus the specified methods are sufficiently sensitive to provide definitive data for the risk assessments for the majority of the chemicals assessed. However, the MDLs for 28 other chemicals are higher than the ACGs derived for human health or ecological RBCs. Therefore, application of the cited analytical methods could result in some uncertainty regarding whether these chemicals represent a significant risk if they were undetected using these standard methods. The MDLs in Table D-11 are the lowest that can be obtained using EPA-approved analytical methods. The chemicals with ACGs lower than these MDLs are nine SVOCs, six individual PCB Aroclors, one PCB congener, six organochlorine pesticides, total and inorganic arsenic, chromium, mercury, selenium, and 2,3,7,8-TCDD (Table D-11).[16] It should be noted that for three SVOCs, chromium, mercury, and four pesticides, only the ACGs based on the total seafood consumption rate of 98g/day are below the MDL, not the ACGs calculated based on consumption rates specific for benthic fish, pelagic fish, and crabs.

[14] The human health-based RBC for a given chemical may be derived from either a carcinogenic or non-carcinogenic endpoint. For chemicals with both endpoints, the lower RBC is shown in Table D-2.

[15] If starry flounder are collected in place of sculpin or English sole, the lower of the ACGs for sculpin or English sole would be applied to starry flounder.

[16] The low extraction procedure with Method 8270C will be used for fish and crab tissue to meet ACGs for PAHs for all tissue samples, except English sole (whole body) and sculpin because these tissues are of low importance in the HHRA; the low detection limits are not required for the ERA.

Elevated MDLs relative to ACGs are only problematic when chemicals are not detected. The laboratory will make additional efforts to achieve ACGs for Aroclors in samples if no Aroclors are detected in a sample. The lab will also make additional efforts to achieve the ACG for PCB congener 126 based on the consumption rate specific to the tissue type if it is not detected in a sample. Additional efforts may include additional sample clean-up, extracting more sample, using a lower concentration for the lowest standard in the initial calibration, adjusting the final volume, or adjusting the amount of extract injected into the instrument. For the other chemicals with MDLs above the ACGs, the ramifications for the Phase 2 HHRA will be discussed in the uncertainty assessment.

All ACGs for sculpin, which are not consumed by humans, are greater than or equal to the MDLs shown in Table D-11, with the exception of selenium, indicating that all analytical methods cited, except EPA Method 7742 for selenium, are sufficiently sensitive. The MDL for selenium of 1.0 mg/kg ww is the lowest that can be obtained using EPA-approved analytical methods.

D.4.0 Tissue Mass Required for Analysis

This section presents the amount of tissue mass required to meet the MDLs presented in Table D-10. This information will be used in the QAPP to set the minimum amount of tissue mass to be targeted for collection.[17]

For English sole, perch, sculpin, and crab, the standard tissue mass required to meet the MDLs for all analytes in Table D-11 is 81 g per composite tissue sample (Table D-13). It will not be difficult to collect this amount of tissue mass for fish tissue samples. However, it may be difficult to collect enough tissue mass for crab edible meat and hepatopancreas samples. Therefore, the relationship between MDL and tissue mass for crab samples was further evaluated.

The MDLs will increase proportionally as the tissue mass decreases.[18] Specifically, if the required tissue mass is decreased by an order of magnitude, the detection limit will increase by an order of magnitude (Salata 2004b). The MDLs in Table D-10 were compared to the ACGs for crab tissue samples to determine whether the MDLS for any chemical analysis type could be increased and still meet the crab ACGs. For crab tissue samples, the only MDL that could be increased based on this comparison is the MDL of 0.00033 mg/kg ww for TBT. The required tissue mass could be reduced from 10 g to a minimum of 2 g, resulting in an MDL of 0.0017 mg/kg ww. This increased MDL remains lower than the crab ACG of 0.028 mg/kg ww. Therefore, the minimum

[17] Tissue mass requirements do not include the amount needed for laboratory quality control samples; thus, additional tissue mass will need to be collected as appropriate (see Section 3.4.2 in the QAPP).

[18] Conversely, it may be possible to decrease MDLs by increasing tissue mass, although the laboratory would need to develop alternative cleanup methods to remove matrix interferences. The MDLs presented in Table D-11 are based on optimal tissue amounts using the laboratory's established standard operating procedures and cleanup methods.

tissue mass for crab whole body or hepatopancreas could be reduced from 81 g to 73 g, as summarized in Table D-13.

D.5.0 Tables

Table D-1. Receptors, exposure pathways, and tissue types for RBCs

RECEPTOR	CHEMICAL EXPOSURE PATHWAY	TISSUE TYPE ASSOCIATED WITH RBC
Fish (sculpin, English sole)	direct contact with water or sediment, or ingestion of food	fish tissue of receptor itself (whole-body sculpin, English sole)
Crab	direct contact with water or sediment, or ingestion of food	crab tissue (edible meat and hepatopancreas, depending on analyte)
Higher-trophic-level fish that includes a piscivorous diet (sculpin)[a]	ingestion of food	prey tissue (whole-body English sole and whole-body perch)[b]
Birds (great blue heron and osprey)	ingestion of food	prey tissue (whole-body sculpin, whole-body English sole, and whole-body perch)
Mammals (river otter and harbor seal)	ingestion of food	prey tissue (whole-body sculpin, whole-body English sole, and whole-body perch; crab edible meat for river otter only)
Humans	ingestion of food	prey tissue (fillet and whole-body English sole; whole-body perch; and crab hepatopancreas and edible meat)[b]

[a] Sculpin consume both fish and benthic invertebrates.

Table D-2. Receptor-specific dietary and critical tissue residue RBCs for fish and crabs

Analyte	Dietary RBC (mg/kg ww)											Critical Tissue Residue RBC (mg/kg ww)			
		Osprey		Great Blue Heron		River Otter		Harbor Seal		Piscivorous Fish		Fish		Crab	
	Human Health[a]	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based
PAHs															
Acenaphthene	46-30	na	na	na	na	na	na	na	na	na	na	nd	nd	na	na
Acenaphthylene	na	na	na	na	na	na	na	na	na	na	na	nd	nd	na	na
Anthracene	25-160	na	na	na	na	na	na	na	na	na	na	nd	nd	na	na
Benzo(a)anthracene	0.0014-0.009	na	na	na	na	na	na	na	na	na	na	nd	nd	na	na
Benzo(a)pyrene	0.00014-0.0009	na	na	na	na	60	na	319	na	16	6.6	nd	nd	na	na
Benzo(b)fluoranthene	0.0014-0.009	na	na	na	na	na	na	na	na	na	na	nd	nd	na	Na
Benzo(k)fluoranthene	0.014-0.09	na	na	na	na	na	na	na	na	na	na	nd	nd	na	Na
Benzo(g,h,i)perylene	Na	na	na	na	na	na	na	na	na	na	na	nd	nd	na	Na
Chrysene	0.14-0.9	na	na	na	na	na	na	na	na	na	na	nd	nd	na	Na
Dibenzo(a,h)anthracene	0.00014-0.0009	na	na	na	na	na	na	na	na	na	na	nd	nd	na	Na
Dibenzofuran	0.33-2.1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	Nd
Fluoranthene	3.3-21	na	na	na	na	na	na	na	na	na	na	nd	nd	na	Na
Fluorene	3.3-21	na	na	na	na	na	na	na	na	na	na	nd	nd	na	Na
Indeno(1,2,3-cd)pyrene	0.0014-0.009	na	na	na	na	na	na	na	na	na	na	nd	nd	na	Na
2-Methylnaphthalene	1.6-11	nd	nd	nd	nd	695	329	3,675	1,741	na	na	nd	nd	na	na
Naphthalene	1.6-11	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
Phenanthrene	na	na	na	na	na	na	na	na	na	na	na	nd	nd	na	na
Pyrene	2.5-16	na	na	na	na	na	na	na	na	na	na	nd	nd	na	na
Total PAHs	na	175	na	228	na	na	na	na	na	na	na	nd	nd	na	na
Other SVOCs															
1,2,4-Trichlorobenzene	0.87-5.7	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
1,2-Dichlorobenzene	7.4-48	na	na	na	na	na	na	na	na	nd	nd	na	na	na	na
1,3-Dichlorobenzene	2.5-16	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na

Analyte	Dietary RBC (mg/kg ww)											Critical Tissue Residue RBC (mg/kg ww)			
		Osprey		Great Blue Heron		River Otter		Harbor Seal		Piscivorous Fish		Fish		Crab	
	Human Health[a]	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based
1,4-Dichlorobenzene	0.042-0.27	na	na	na	na	653	329	3,450	1,741	nd	nd	na	na	212	na
2,4,5-Trichlorophenol	8.7-57	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
2,4,6-Trichlorophenol	0.097-0.63	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
2,4-Dichlorophenol	0.25-1.6	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
2,4-Dimethylphenol	1.6-11	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
2,4-Dinitrophenol	0.16-1.1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
2,4-Dinitrotoluene	0.16-1.1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
2,6-Dinitrotoluene	0.078-0.51	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
2-Chloronaphthalene	6.4-42	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
2-Chlorophenol	0.41-2.7	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
2-Methylphenol	4.1-27	na	na	na	na	na	na	na	na	nd	nd	na	na	na	na
3,3'-Dichlorobenzidine	0.0023-0.015	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
4-Chloroaniline	0.33-2.1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
4-Methylphenol	0.41-2.7	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
4-Nitrophenol	0.64-4.2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
Aniline	0.18-1.2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
Benzidine	0.0000046-0.000030	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
Benzoic acid	330-2100	na	na	na	na	na	na	na	na	nd	nd	na	na	na	na
Benzyl alcohol	25-160	na	na	na	na	na	na	na	na	nd	nd	na	na	na	na
Bis(2-chloroethyl)ether	0.00097-0.0063	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
Bis(2-ethylhexyl)phthalate	0.074-0.48	1,455	6.6	1,865	8.5	545	419	2,901	2,231	nd	nd	1.5	0.39	na	na
Bis-chloroisopropyl ether	0.015-0.096	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Butyl benzyl phthalate	16-110	nd	nd	nd	nd	5,154	5,069	27,243	26,791	nd	nd	nd	nd	na	na
Carbazole	0.051-0.33	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
Di-ethyl phthalate	64-420	nd	nd	nd	nd	22,270	11,132	118,607	59,288	nd	nd	nd	nd	na	na
Dimethyl phthalate	870-5700	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
Di-n-butyl phthalate	8.7-57	nd	nd	nd	nd	479	na	2,550	na	nd	nd	nd	nd	0.50	na
Di-n-octyl phthalate	1.6-11	nd	nd	nd	nd	na	44,886	na	239,063	nd	nd	nd	nd	na	na

Analyte	Dietary RBC (mg/kg ww)											Critical Tissue Residue RBC (mg/kg ww)			
		Osprey		Great Blue Heron		River Otter		Harbor Seal		Piscivorous Fish		Fish		Crab	
	Human Health[a]	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based
Hexachlorobutadiene	0.013-0.084	14	na	18	na	0.78	na	4.1	na	nd	nd	na	na	na	na
Hexachloroethane	0.074-0.48	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
Isophorone	1.1-7.2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
Nitrobenzene	0.043-0.28	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
N-Nitrosodimethylamine	0.000021-0.00014	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
N-Nitrosodi-n-propylamine	0.00015-0.00096	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
N-Nitrosodiphenylamine	0.21-1.4	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
Pentachlorophenol	0.0087-0.057	275	96	359	125	78	24	414	128	nd	nd	nd	nd	na	na
Phenol	46-300	na	na	na	na	na	na	na	na	nd	nd	na	na	na	na
PCBs															
Aroclor 1016	0.015-0.096	na	na	na	na	na	na	na	na	nd	nd	na	na	na	na
Aroclor 1221	0.00051-0.0033	na	na	na	na	na	na	na	na	nd	nd	na	na	na	na
Aroclor 1232	0.00051-0.0033	na	na	na	na	na	na	na	na	nd	nd	na	na	na	na
Aroclor 1242	0.00051-0.0033	na	na	na	na	na	na	na	na	nd	nd	na	na	na	na
Aroclor 1248	0.00051-0.0033	na	1.8	na	2.3	na	na	na	na	nd	nd	na	na	na	na
Aroclor 1254	0.00051-0.0033	4.2	na	5.3	na	0.53	na	2.8	na	nd	nd	nd	3.7	na	23
Aroclor 1260	0.00051-0.0033	na	na	na	na	na	na	na	na	nd	nd	na	na	na	na
PCB-77 [b]	6.8E-5 – 4.5E-4	0.088	0.0088	0.114	0.0114	0.6	0.06	3.2	0.32	nd	nd	nd	nd	nd	nd
PCB-81 [b]	6.8E-5 – 4.5E-4	0.044	0.0044	0.057	0.0057	0.6	0.06	3.2	0.32	nd	nd	nd	nd	nd	nd
PCB-105 [b]	6.8E-5 – 4.5E-4	44	0.44	57	0.57	0.6	0.06	3.2	0.32	nd	nd	nd	nd	nd	nd
PCB-114 [b]	1.4E-5 – 8.9E-5	44	0.44	57	0.57	0.12	0.012	0.64	0.064	nd	nd	nd	nd	nd	nd

Analyte	Dietary RBC (mg/kg ww)											Critical Tissue Residue RBC (mg/kg ww)			
		Osprey		Great Blue Heron		River Otter		Harbor Seal		Piscivorous Fish		Fish		Crab	
	Human Health[a]	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based
PCB-118 [b]	6.8E-5 – 4.5E-4	440	44	570	57	0.6	0.06	3.2	0.32	nd	nd	nd	nd	nd	nd
PCB-123 [b]	6.8E-5 – 4.5E-4	440	44	570	57	0.6	0.06	3.2	0.32	nd	nd	nd	nd	nd	nd
PCB-126 [b]	6.8E-8 – 4.5E-7	0.044	0.0044	0.057	0.0057	0.0006	0.00006	0.0032	0.00032	nd	nd	nd	nd	nd	nd
PCB-156 [b]	1.4E-5 – 8.9E-5	44	0.44	57	0.57	0.12	0.012	0.64	0.064	nd	nd	nd	nd	nd	nd
PCB-157 [b]	1.4E-5 – 8.9E-5	44	0.44	57	0.57	0.12	0.012	0.64	0.064	nd	nd	nd	nd	nd	nd
PCB-167 [b]	6.8E-4 – 4.5E-3	440	44	570	57	6.0	0.6	32	3.2	nd	nd	nd	nd	nd	nd
PCB-169 [b]	6.8E-7 – 4.5E-6	4.4	0.44	5.7	0.57	0.006	0.0006	0.032	0.0032	nd	nd	nd	nd	nd	nd
PCB-189 [b]	6.8E-5 – 4.5E-4	440	44	570	57	0.6	0.06	3.2	0.32	nd	nd	nd	nd	nd	nd
Dioxins/furans										nd	nd	nd	nd	nd	nd
2,3,7,8-TCDD	6.9E-9 – 4.5E-8	0.0044	0.00044	0.0057	0.00057	6.0×10^{-5}	6.0×10^{-6}	3.2×10^{-4}	3.2×10^{-5}	nd	nd	1.5×10^{-4}	7.2×10^{-5}	na	na
Metals															
Antimony	0.033-0.21	na	na	na	na	na	9082	na	48,005	na	na	na	na	na	na
Arsenic	0.00069-0.0045	170	87	222	114	33	16	174	84	10	7.8	na	na	na	1.15
Cadmium	0.087-0.57	205	87	267	114	79	21	419	113	23	17	na	na	9.5	4.9
Chromium	0.25-1.6	459	34	598	44	na	8942	na	47,264	na	na	na	na	3.2	1.0
Cobalt	1.6-11	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Copper	3.3-21	271	205	353	267	156	108	829	574	na	62	na	na	na	34
Lead	na	88	34	113	43	539	66	2,869	351	na	6,336	na	na	100	66
Mercury	0.0083-0.054	0.40	na	0.52	na	1.5	1.0	8.1	5.2	na	na	0.2	0.47	na	1.64
Molybdenum	0.41-2.7	156	na	200	na	na	na	na	na	na	na	na	na	na	na
Nickel	1.6-11	468	336	609	438	531	51	2,805	271	6.6	3.5	na	na	na	na
Selenium	0.41-2.7	3.63	1.9	4.6	2.38	0.73	0.57	3.9	3.0	na	2,700	na	na	na	na
Silver	0.41-2.7	na	na	na	na	na	na	na	na	na	na	na	na	na	na

Analyte	Dietary RBC (mg/kg ww)											Critical Tissue Residue RBC (mg/kg ww)			
		Osprey		Great Blue Heron		River Otter		Harbor Seal		Piscivorous Fish		Fish		Crab	
	Human Health[a]	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based
Thallium	0.0055-0.036	nd	nd	nd	nd	nd	nd	nd	nd	na	na	nd	nd	na	na
Vanadium	0.55-3.6	na	na	na	na	na	na	na	na	1,800	380	na	na	na	na
Zinc	25-160	542	358	706	467	2,418	1,209	12,878	6,439	na	na	na	na	35.2	12.7
Di-n-butyltin	na	na	na	na	na	na	na	na	na	nd	nd	na	na	na	na
Tri-n-butyltin	0.012-0.078	74.7	30	96	38.6	14	1.4	74	7.4	nd	nd	1.7	0.26	na	na
Organochlorine Pesticides															
4,4'-DDD	0.0042-0.027	4.0	na	5.1	na	na	na	na	na	nd	nd	na	na	na	na
4,4'-DDE	0.003-0.020	1.2	0.57	1.6	0.74	na	na	na	na	nd	nd	na	na	na	na
4,4'-DDT	0.003-0.020	4.4	4.0	5.7	5.1	na	na	na	na	nd	nd	na	na	na	na
Total DDT	0.003-0.020	na	na	na	na	7.8	7.2	41	38	nd	nd	3.0	1.9	na	0.060
Aldrin	0.000059-0.00039	0.17	na	0.23	na	25	5.1	132	27	nd	nd	na	5.3	na	na
alpha-BHC	0.00016-0.0011	na	na	na	na	na	na	na	na	nd	nd	na	na	na	na
beta-BHC	0.00059-0.0039	nd	nd	nd	nd	189	35	999	184	nd	nd	nd	nd	na	na
Chlordane	0.0029-0.019	240	6.1	313	8.0	5.6	1.1	30	5.8	nd	nd	17	na	0.71	0.49
Dieldrin	0.000064-0.00042	2.1	1.0	2.7	1.4	5.5	na	29	na	nd	nd	0.20	0.12	na	na
Endosulfan	0.46-3.0	na	93	na	119	15	5.1	81	27	nd	nd	0.031	na	na	na
Endosulfan sulfate	na	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
Endrin	0.025-0.16	1.2	0.71	1.6	0.91	5.5	na	29	na	nd	nd	0.012	na	na	na
gamma-BHC (Lindane)	0.00078-0.0051	16	7.1	20	9.1	na	37	na	194	nd	nd	9.5	6.1	na	na
Heptachlor	0.00023-0.0015	nd	nd	nd	nd	11	6.0	57	32	nd	nd	1.5	na	na	na
Heptachlor epoxide	0.00011-0.00072	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
Hexachlorobenzene	0.00064-0.0042	14	na	18	na	0.78	na	4.1	na	nd	nd	na	468	na	na
Methoxychlor	0.41-2.7	na	na	na	na	335	na	1785	na	nd	nd	1.6	0.060	0.10	na

Analyte	Dietary RBC (mg/kg ww)											Critical Tissue Residue RBC (mg/kg ww)			
		Osprey		Great Blue Heron		River Otter		Harbor Seal		Piscivorous Fish		Fish		Crab	
	Human Health[a]	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based	LOAEL-Based	NOAEL-Based
Mirex	0.016-0.11	150	80	193	102	2.4	1.4	13	7.3	nd	nd	nd	nd	na	na
Toxaphene	0.00097-0.0063	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na

na – toxicity data not available or not applicable based on the selection criteria discussed in Sections D.2.1.1, D.2.2.1, D.2.3.1, and D.2.4.1.

nd – not determined because risk will be assessed using another approach (i.e., critical tissue residue approach for fish) or not included in Table D-3

[a] The RBC for a given chemical may be derived from either carcinogenic or non-carcinogenic endpoints. For chemicals with both endpoints, the lower RBC is shown. The RBC is dependent on the assumed consumption for a specific seafood type. The RBCs presented were calculated using two seafood consumption rates: 15 g/day and 98 g/day, as described in Section D.2.5.

[b] Dioxin-like PCB congeners will be evaluated as toxic equivalents (TEQs) in the risk assessments, rather than as individual congeners. However, because TEQs are calculated, rather than measured by the laboratory, RBCs for individual PCB congeners are presented to facilitate comparison with MDLs for those congeners. In reality, risks will be assessed based on sums of these congeners (normalized per their relative toxicity to TCDD), and thus comparison to MDLs on a congener-specific basis is somewhat uncertain.

Table D-3. Chemicals of interest in tissue based on draft tissue analyte approach memorandum (Windward 2003a)

Metals	PAHs
Antimony	Acenaphthene
Arsenic	Acenaphthylene
Cadmium	Anthracene
Chromium	Benzo(a)anthracene
Cobalt	Benzo(a)pyrene
Copper	Benzo(b)fluoranthene
Lead	Benzo(g,h,i)perylene
Mercury	Benzo(k)fluoranthene
Molybdenum	Chrysene
Nickel	Dibenzo(a,h)anthracene
Selenium	Fluoranthene
Silver	Fluorene
Vanadium	Indeno(1,2,3-cd)pyrene
Zinc	Phenanthrene
Butyltins	Pyrene
Dibutyltin as ion	**PCBs**
Tributyltin as ion	Total PCBs
Organochlorine Pesticides	**SVOCs**
4,4'-DDD	1,2-Dichlorobenzene
4,4'-DDE	1,4-Dichlorobenzene
4,4'-DDT	2-Methylphenol
alpha-BHC	Benzoic acid
gamma-BHC	Benzyl alcohol
Chlordane (alpha and gamma)	Bis(2-ethylhexyl)phthalate
Dieldrin	Di-n-butyl phthalate
Hexachlorobenzene	Hexachlorobenzene
Methoxychlor	Pentachlorophenol
	Phenol

Table D-4. Studies selected to derive critical tissue residue RBCs for crabs

Analyte	NOEC (mg/kg ww)	LOEC (mg/kg ww)	Endpoint	Test Species	Exposure Pathway	Reference
Aroclor 1254	23	na	survival	blue crab (juvenile)	water	Duke et al. 1970
Arsenic	1.15[a]	na	growth	grass shrimp (juvenile)	water	Lindsay and Sanders 1990
Cadmium	4.9[a]	9.5[a]	survival	shore crab	water	Jennings and Rainbow 1979
Chromium	1	3.2	growth	sand crab (juvenile)	water	Mortimer and Miller 1994
Copper	34[a,b]	na	survival	crayfish	water	Evans 1980
Lead	66[a,b]	100[a,b]	survival	Indian prawn	water	Chinni et al. 2002
Mercury	1.64	na	survival	grass shrimp	water	Barthalmus 1977
Zinc	12.7[a]	35.2[a]	survival	crayfish	water	Mirenda 1986
Chlordane	0.49[b]	0.71[b]	survival	pink shrimp	water	Parrish et al. 1976
Total DDT	na	0.06	survival	pink shrimp	water	Nimmo et al. 1970
Methoxychlor	na	<0.1[c]	survival	blue crab	water	Bookhout et al. 1976.
1,4-Dichlorobenzene	na	212[d]	survival	sand crab	water	Mortimer and Connell 1994
Di-n-butyl phthalate	na	0.5[e]	survival	grass shrimp	water	Laughlin et al. 1978

Note: Tissue types analyzed include whole body, muscle, or claws.

na – NOEC or LOEC not available or not applicable based on the selection criteria discussed in Section D.2.1.1

[a] Converted to wet weight assuming 20% solids (a typical solids content in aquatic organisms)

[b] Acute exposure periods, which ranged from 48 to 96 hours

[c] Tissue concentrations below detection limit.

[d] Tissue concentration estimated based on measured uptake and depuration rates.

[e] Estimated based on detection limits between 0.5 and 2 mg/kg ww

Table D-5. Studies selected to derive critical tissue residue RBCs for fish

Analyte	NOEC (mg/kg ww)	LOEC (mg/kg ww)	Endpoint[a]	Test Species	Exposure Pathway	Reference
2,3,7,8-TCDD	0.000072	0.00015	growth	rainbow trout	diet	Fisk et al. 1997
Aroclor 1254	na	3.72[b]	growth	Rainbow trout	diet	Hendricks et al. 1981
Mercury	0.2	0.47	survival	mummichog	water	Matta et al. 2001
TBT	0.26	na	survival	guppy	water	Tsuda et al. 1990
TBT	na	1.7[c]	survival	starry flounder	water	Meador 1997
Aldrin	5.3	na	survival/growth	Atlantic salmon	injection	Addison et al. 1976
Chlordane	na	16.6	survival	pinfish	water	Parrish et al. 1976
Total DDT	na	3.0	survival/reproduction	coho salmon and brook trout	water and diet	Allison et al. 1964; Macek 1968
Total DDT	1.92	na	survival	brook trout	diet	Macek & Korn 1970
Dieldrin	0.12	0.20	survival	rainbow trout	water and diet	Shubat & Curtis 1986
Endrin	na	0.0115	survival	largemouth bass	water	Fabacher 1976
Endosulfan	na	0.031	survival	spot	water	Schimmel et al. 1977
Heptachlor	na	1.5	survival	spot	water	Schimmel et al. 1976
Lindane	6.13	9.53	survival	fathead minnow	water	Macek et al. 1976
Hexachlorobenzene	468	na	survival	fathead minnow	water	Schuytema et al. 1990
Methoxychlor	0.06	1.64	survival	mullet- juvenile	water	Lee et al. 1975
Bis(2-ethylhexyl)phthalate	0.39[C]	1.6[C]	survival	rainbow trout	water	Mehrle and Mayer 1976

na – NOEC or LOEC not available or not applicable based on the selection criteria discussed in Section D.2.2.1

[a] The NOEC and/or LOEC presented applies to all endpoints listed for a specific chemical.

[b] Conversion factor (sac-fry to adult) applied based on Niimi (1983)

[c] Tissue residues based on reported bioconcentration factor and water concentration

Table D-6. Studies selected to derive RBCs in prey items of fish

Analyte	NOEC (mg/kg ww)	LOEC (mg/kg ww)	Endpoint	Test Species	Exposure Pathway	Reference
Arsenic	7.76[a]	10.4[a]	growth	rainbow trout	food	Hocket et al. 2003
Cadmium	na	17.26[b]	growth	guppy	food	Hatakeyama and Yasuno 1982
Cadmium	22.8[a]	na	growth	rainbow trout	food	Erickson et al. 2003
Copper	61.6[a]	na	growth	rainbow trout	food	Erickson et al. 2003
Lead	6,336[c]	na	growth	rainbow trout	food	Goettl et al. 1976
Selenium	3.5	6.6	survival	bluegill juveniles	food	Cleveland et al. 1993
Silver	2,700[c]	na	growth	rainbow trout	food	Galvez and Wood 1999
Zinc	na	1,800[c]	growth	rainbow trout	food	Takeda and Shimma 1977
Zinc	380[a]	na	growth	rainbow trout	food	Mount et al. 1994
Benzo(a)pyrene	6.58[d]	16.24[d]	growth	English sole	food	Rice et al. 2000

na – NOAEL or LOAEL not available or not applicable based on the selection criteria discussed in Section D.2.3.1

Note: Conversions to wet weight were based on type of food or prey species used in each study.

[a] Converted to wet weight assuming 20% solids in prey (a typical solids content in aquatic organisms)

[b] Converted to wet weight using measured 13.7% solids in midge prey from a separate study (Hatakeyama and Yasuno 1987)

[c] Converted to wet weight assuming 90% solids in prepared food (Palm et al. 2003)

[d] Converted to wet weight assuming 14% solids in *Armandia brevis* (Windward unpublished data)

Table D-7. Studies selected to derive RBCs in prey items of birds

Analyte	NOAEL (mg/kg bw/day)	LOAEL (mg/kg bw/day)	Endpoint[a]	Test Species	Exposure Pathway	Reference
2,3,7,8-TCDD	0.0001	0.001	survival	white leghorn, cockerels	gavage	Schwetz et al. 1973
Aroclor 1254	na	0.94	reproduction	ringed turtledove	food	Peakall et al. 1972
Aroclor 1248	0.41	na	reproduction	screech owl	food	McLane and Hughes 1980
Arsenic	20	39	survival	mallard	food	USFWS 1964
Cadmium	na	47	growth	mallard	food	DiGiulio and Scanlon 1984
Cadmium	20	na	growth	mallard	food	White and Finley 1978
Chromium	na	105	growth	chicks	food	Chung et al. 1988
Chromium	7.7	na	growth	chicks	food	Romoser et al. 1961
Copper	47	62	growth/ survival	chicks	food	Mehring et al. 1960
Lead	na	20	reproduction	Japanese quail	food	Edens et al. 1976
Lead	7.65	na	reproduction/ survival	American kestrel	food	Pattee 1984
Mercury	na	0.091	growth	great egret (1 day old)	food	Spalding et al. 2000
Molybdenum	na	35.3	reproduction	chicken	food	Lepore and Miller 1965
Nickel	77	107	growth/ survival	mallard	food	Cain and Pafford 1981
Selenium	0.42	0.82	reproduction	mallard	food	Heinz et al. 1989
Zinc	82	123	growth	white rock chicks	food	Roberson and Schaible 1960
Tributyltin	6.8	16.9	reproduction	Japanese quail	food	Schlatterer et al. 1993
PAHs[b]	na	40	growth	mallard	food	Patton and Dieter 1980
Aldrin	na	0.040	survival	quail	food	DeWitt et al. 1956
Chlordane	na	55	survival	bobwhite- juvenile	food	Hill et al. 1975
Chlordane	1.4	na	growth/ survival	bobwhite quail	food	Ludke 1976
DDD	na	0.90	reproduction	mallard	food	Heath et al. 1969
DDE	na	0.28	reproduction	barn owl	food	Mendenhall et al. 1983
DDE	0.13	na	reproduction	American kestrel	food	Lincer 1975
DDT	na	1.0	reproduction	Mallard	food	Kolaja 1977

Analyte	NOAEL (mg/kg bw/day)	LOAEL (mg/kg bw/day)	Endpoint[a]	Test Species	Exposure Pathway	Reference
DDT	0.90	na	reproduction	Mallard	food	Heath et al. 1969
Dieldrin	0.24	0.47	survival	bobwhite quail	food	Fergin and Shafer 1977
Endosulfan	21	na	reproduction	gray partridge	food	Abiola 1992
Endrin	na	0.28	reproduction	screech owl	food	Fleming et al. 1982
Endrin	0.16	na	reproduction	Pheasant	food	DeWitt 1956
Hexachlorobenzene	na	3.1	reproduction	Japanese quail	food	Schwetz et al. 1974
Hexachlorobutadiene	4.7	na	growth/ reproduction	Japanese quail	food	Schwetz et al. 1974
gamma-BHC (Lindane)	1.6	3.6	reproduction	Mallard	gavage	Chakravarty and Lahiri 1986; Chakravarty et al. 1986
Mirex	18	34	reproduction	Chicken	food	Naber and Ware 1965
Pentachlorophenol	22	63	growth	broiler chicks	food	Prescott et al. 1982
Bis(2-ethylhexyl) phthalate	na	350	reproduction	Chicken	food	Ishida et al. 1982
Bis(2-ethylhexyl) phthalate	1.5	na	reproduction	ringed turtledove	food	Peakall 1974

na – NOAEL or LOAEL not available or not applicable based on the selection criteria discussed in Section D.2.4.1

[a] The NOEC and/or LOEC presented applies to all endpoints listed for a specific chemical.

[b] Food contained a mixture of paraffins and aromatic hydrocarbons, including acenaphthylene, acenaphthene, and phenanthrene.

Table D-8. Studies selected to derive RBCs in prey items of mammalian wildlife

Analyte	NOAEL (mg/kg bw/day)	LOAEL (mg/kg bw/day)	Endpoint[a]	Test Species	Exposure Pathway	Reference
2,3,7,8-TCDD	0.0000010	0.000010	reproduction	rat	food	Murray et al. 1979
Aroclor 1254	na	0.089	reproduction	mink	food	Brunström et al. 2001
Antimony	1,489	na	growth	rat	food	Hext et al. 1999
Arsenic	2.6	5.4	growth	rat	food	Byron et al. 1967
Cadmium	3.5	13	growth	rat	food	Machemer and Lorke 1981
Chromium	1,466	na	survival	rat	food	Ivankovic and Preussman 1975
Copper	18	26	reproduction	mink	food	Aulerich et al. 1982
Lead	11	90	reproduction	rat	food	Azar et al. 1973
Mercury	0.16	0.25	growth/ survival	mink	food	Wobeser et al. 1976
Nickel	8.4	87	growth	rat	food	Ambrose et al. 1976
Selenium	0.094	0.12	growth	rat	food	Halverson et al. 1966
Zinc	202	404	reproduction	rat	food	Schlicker and Cox 1968
Tributyltin	0.23	2.3	growth	rat	food	Wester et al. 1990
Benzo(a)pyrene	na	10	reproduction	mouse	gavage	MacKenzie and Angevine 1981
2-Methylnaphthalene	54	114	growth	mouse	food	Murata et al. 1997
Aldrin	0.83	4.1	survival	rat	food	Fitzhugh et al. 1964
Chlordane	0.18	0.92	growth	mouse	food	Khasawinah and Grutsch 1989
Total DDT	na	1.3	reproduction	mouse	food	Ware and Good 1967
Total DDT	1.2	na	reproduction	rat	food	Duby et al. 1971
Dieldrin	na	0.92	reproduction	mouse	food	Good and Ware 1969
Endosulfan	0.84	2.5	survival/ growth	mouse	food	Hack et al. 1995
Endrin	na	0.92	reproduction	mouse	food	Good and Ware 1969
Heptachlor	1.0	1.8	survival/ growth/ reproduction	mink	food	Crum et al. 1993
Hexachlorobenzene	na	0.13	reproduction	mink/ ferret	food	Bleavins et al. 1984
Hexachlorobutadiene	2.0	20	survival/ growth/	rat	food	Kociba et al. 1977

Analyte	NOAEL (mg/kg bw/day)	LOAEL (mg/kg bw/day)	Endpoint[a]	Test Species	Exposure Pathway	Reference
			reproduction			
gamma-BHC (Lindane)	6.1	na	reproduction	rat	food	Palmer et al. 1978
beta-BHC	5.7	31	survival/ growth	rat	food	Van Velsen et al. 1986
Methoxychlor	na	56	growth/ reproduction	rat	food	You et al. 2002
Mirex	na	0.40	reproduction	rat	food	Chu et al. 1981
Mirex	0.23	na	reproduction	mouse	food	Wolfe et al. 1979
Pentachlorophenol	4.0	13	reproduction	rat	food	Welsh et al. 1987
Butyl benzyl phthalate	na	845	growth	rat	food	Ema et al. 1994
Butyl benzyl phthalate	831	na	growth	rat	food	Agarwal et al. 1985
Bis (2-ethylhexyl) phthalate	na	91	reproduction	mouse	food	Tyl et al. 1988
Bis (2-ethylhexyl) phthalate	70	na	reproduction	mouse	food	Shiota et al. 1980
Diethyl phthalate	1,860	3,721	growth/reproduction	mouse	food	Lamb et al. 1987
Di-n-butyl phthalate	na	80	reproduction	rat	food	Wine et al. 1997
Di-n-octyl phthalate	7,500	na	reproduction	mouse	food	Heindel et al. 1989
1,4-dichlorobenzene	54	107	growth	rat	gavage	Lake et al. 1997

na – NOAEL or LOAEL not available or not applicable based on the selection criteria discussed in Section D.2.4.1.

[a] The NOEC and/or LOEC presented applies to all endpoints listed for a specific chemical.

Table D-9. Body weights and daily food consumption values used to derive RBCs for birds and mammals

Receptor	Body Weight (kg)	Reference	Daily Food Consumption (kg ww/day)	Method and Reference
Female osprey	1.57	Brown and Amadon 1968, as cited in EPA 1993	0.355	Function of metabolic rate and caloric content of prey (Nagy 1987, as cited in EPA 1993)
Average male and female osprey	1.49		0.341	
Female great blue heron	2.20	Hartman 1961, as cited in EPA 1993	0.388	Allometric equation for wading birds (Kushlan 1978)
Average male and female great blue heron	2.39		0.342	
Female river otter	7.9	Melquist and Hornocker 1983, as cited in EPA 1993	1.32	Function of metabolic rate and caloric content of prey (Nagy 1987, as cited in EPA 1993)
Average male and female river otter	8.55		1.41	
Female harbor seal	76.5	Pitcher and Caulkins 1979, as cited in EPA 1993	2.40	Allometric equation for harbor seals (Boulva and McLaren 1979, as cited in EPA 1993)
Average male and female harbor seal	80.6		2.50	

Table D-10. RBCs used to derive ACGs for fish and crab tissue

Fish or Crab Tissue	RBC Used to Derive ACG	
	Receptor-Specific Dietary RBC	Receptor-Specific Critical Tissue Residue RBC
Sculpin (whole body)	bird (osprey and great blue heron) mammal (river otter and harbor seal)	fish (i.e., sculpin)
English sole (whole body)	bird (osprey and great blue heron) mammal (river otter and harbor seal) piscivorous fish (i.e., sculpin)	fish (i.e., English sole)
English sole (fillet)	human (based on benthic fish ingestion rate)	na
Perch whole body	bird (osprey and great blue heron) mammal (river otter and harbor seal)human (based on pelagic fish ingestion rate) piscivorous fish (sculpin)	na
Crab (edible meat)	mammal (river otter and harbor seal) human (based on crab ingestion rate)	crab

na – not applicable

Table D-11. Comparison of MDLs and ACGs

Method and Analyte	MDL[a] (mg/kg ww)		ACGs (mg/kg ww)[b]					Sample type and receptor with ACG lower than MDL
			Sculpin Whole Body	English sole Whole Body	English Sole Fillet	Perch Whole Body	Crab Edible Meat[c]	
EPA Method 8270C								
PAHs	***Low-level extraction***	***Standard extraction***						
Acenaphthene	0.000074	0.0045	na[d]	na[d]	4.6-30	4.6-28	4.6-9.9	
Acenaphthylene	0.000050	0.0052	na[d]	na[d]	na[d]	na[d]	na[d]	
Anthracene	0.000055	0.0047	na[d]	na[d]	25-160	25-150	25-53	
Benzo(a)anthracene	0.000054	0.0055	na[d]	na[d]	0.0014-0.009	0.0014-0.0085	0.0014-0.0030	
Benzo(a)pyrene	0.000076	0.0034	60	6.6	0.00014-0.0009	0.00014-0.00085	0.00014-0.00030	
Benzo(b)fluoranthene	0.000045	0.0035	na[d]	na[d]	0.0014-0.009	0.0014-0.0085	0.0014-0.0030	
Benzo(k)fluoranthene	0.000081	0.0034	na[d]	na[d]	0.014-0.09	0.014-0.085	0.014-0.030	
Benzo(g,h,i)perylene	0.000097	0.0053	na[d]	na[d]	na[d]	na[d]	na[d]	
Chrysene	0.000080	0.0028	na[d]	na[d]	0.14-0.9	0.14-0.85	0.14-0.30	
Dibenzo(a,h)anthracene	0.000079	0.0060	na[d]	na[d]	0.00014-0.0009	0.00014-0.00085	0.00014-0.00030	
Dibenzofuran	0.000052	0.0053	na[d]	na[d]	0.33-2.1	0.33-2.0	0.33-0.69	
Fluoranthene	0.000053	0.0067	na[d]	na[d]	3.3-21	3.3-20	3.3-6.9	
Fluorene	0.000054	0.0060	na[d]	na[d]	3.3-21	3.3-20	3.3-6.9	
Indeno(1,2,3-cd)pyrene	0.000073	0.0031	na[d]	na[d]	0.0014-0.009	0.0014-0.0085	0.0014-0.0030	
2-Methylnaphthalene	0.00015	0.0040	329	329	1.6-11	1.6-10	1.6-3.6	
Naphthalene	0.00026	0.0040	na[d]	na[d]	1.6-11	1.6-10	1.6-3.6	
Phenanthrene	0.000066	0.0050	na[d]	na[d]	na[d]	na[d]	na[d]	
Pyrene	0.000070	0.0082	na[d]	na[d]	2.5-16	2.5-15	2.5-5.3	
Total PAHs	0.0013[e]	0.071[e]	175	175	na	na	na	

Method and Analyte	MDL[a] (mg/kg ww)	ACGs (mg/kg ww)[b]					Sample type and receptor with ACG lower than MDL
		Sculpin Whole Body	English sole Whole Body	English Sole Fillet	Perch Whole Body	Crab Edible Meat[c]	
Other SVOCs							
1,2,4-Trichlorobenzene	0.0048	nd	nd	0.87-5.7	0.87-5.4	0.87-1.9	
1,2-Dichlorobenzene	0.0050	na	na	7.4-48	7.4-45	7.4-16	
1,3-Dichlorobenzene	0.0050	nd	nd	2.5-16	2.5-15	2.5-5.3	
1,4-Dichlorobenzene	0.0054	329	329	0.042-0.27	0.042-0.25	0.042-0.089	
2,4,5-Trichlorophenol	0.031	nd	nd	8.7-57	8.7-54	8.7-19	
2,4,6-Trichlorophenol	0.022	nd	nd	0.097-0.63	0.097-0.59	0.097-0.21	
2,4-Dichlorophenol	0.020	nd	nd	0.25-1.6	0.25-1.5	0.25-0.53	
2,4-Dimethylphenol	0.042	nd	nd	1.6-11	1.6-10	1.6-3.6	
2,4-Dinitrophenol	0.19	nd	nd	0.16-1.1	0.16-1.0	0.16-0.36	English sole fillet, perch, and crab (using total seafood rate only), human health
2,4-Dinitrotoluene	0.018	nd	nd	0.16-1.1	0.16-1.0	0.16-0.36	
2,6-Dinitrotoluene	0.0062	nd	nd	0.078-0.51	0.078-0.48	0.078-0.17	
2-Chloronaphthalene	0.0059	nd	nd	6.4-42	6.4-39	6.4-14	
2-Chlorophenol	0.033	nd	nd	0.41-2.7	0.41-2.5	0.41-0.89	
2-Methylphenol	0.025	nd	nd	4.1-27	4.1-25	4.1-8.9	
3,3'-Dichlorobenzidine	1.3	nd	nd	0.0023-0.015	0.0023-0.014	0.0023-0.005	English sole fillet, perch, and crab; human health
4-Chloroaniline	0.093	nd	nd	0.33-2.1	0.33-2.0	0.33-0.69	
4-Methylphenol	0.028	nd	nd	0.41-2.7	0.41-2.5	0.41-0.89	
4-Nitrophenol	0.15	nd	nd	0.64-4.2	0.64-3.9	0.64-1.4	

Method and Analyte	MDL[a] (mg/kg ww)	ACGs (mg/kg ww)[b]					
		Sculpin Whole Body	English sole Whole Body	English Sole Fillet	Perch Whole Body	Crab Edible Meat[c]	Sample type and receptor with ACG lower than MDL
Aniline	0.23	nd	nd	0.18-1.2	0.18-1.1	0.18-0.40	English sole fillet, perch, and crab (using total seafood rate only), human health
Benzidine	5.0	nd	nd	4.6E-6 – 3.0E-5	4.6E-6 – 2.8E-5	4.6E-6 – 9.9E-6	English sole fillet, perch, and crab; human health
Benzoic acid	0.065	nd	nd	330-2100	330-2000	330-690	
Benzyl alcohol	0.014	nd	nd	25-160	25-150	25-53	
bis(2-chloroethyl)ether	0.0028	nd	nd	0.00097-0.0063	0.00097-0.0059	0.00097-0.0021	crab; human health English sole fillet and perch (using total seafood rate only); human health
bis(2-ethylhexyl)phthalate	0.14	0.39	0.39	0.074-0.48	0.074-0.45	0.074-0.16	English sole fillet, perch, and crab (using total seafood rate only), human health
bis-chloroisopropyl ether	0.011	nd	nd	0.015-0.096	0.015-0.090	0.015-0.032	
Butyl benzyl phthalate	0.019	5,069	5,069	16-110	16-100	16-36	
Carbazole	0.0051	nd	nd	0.051-0.33	0.051-0.31	0.051-0.11	
Di-ethyl phthalate	0.034	11,132	11,132	64-420	64-390	64-140	
Dimethyl phthalate	0.0053	nd	nd	870-5700	870-5400	870-1900	
Di-n-butyl phthalate	0.0060	479	479	8.7-57	8.7-54	8.7-19	
Di-n-octyl phthalate	0.0070	44,886	44,886	1.6-11	1.6-10	1.6-3.6	
Hexachlorobutadiene	0.0052	0.78	0.78	0.013-0.084	0.013-0.079	0.013-0.028	
Hexachloroethane	0.0050	nd	nd	0.074-0.48	0.074-0.45	0.074-0.16	
Isophorone	0.0013	nd	nd	1.1-7.2	1.1-6.8	1.1-2.4	

Method and Analyte	MDL[a] (mg/kg ww)	ACGs (mg/kg ww)[b]					Sample type and receptor with ACG lower than MDL
		Sculpin Whole Body	English sole Whole Body	English Sole Fillet	Perch Whole Body	Crab Edible Meat[c]	
Nitrobenzene	0.0075	nd	nd	0.043-0.28	0.043-0.26	0.043-0.092	
N-Nitrosodimethylamine	0.010	nd	nd	2.1E-5 – 1.4E-4	2.1E-5 – 1.3E-4	2.1E-5 – 4.6E-5	English sole fillet, perch, and crab; human health
N-Nitrosodi-n-propylamine	0.013	nd	nd	0.00015-0.00096	0.00015-0.0009	0.00015-0.00032	English sole fillet, perch, and crab; human health
N-Nitrosodiphenylamine	0.0095	nd	nd	0.21-1.4	0.21-1.3	0.21-0.46	
Pentachlorophenol	0.091	24	24	0.0087-0.057	0.0087-0.054	0.0087-0.019	English sole fillet, perch, and crab; human health
Phenol	0.054	na	na	46-300	46-280	46-99	
EPA Method 8082							
Aroclor 1016	0.0020	na	na	0.015-0.096	0.015-0.090	0.015-0.032	
Aroclor 1221	0.0031	na	na	0.00051-0.0033	0.00051-0.0031	0.00051-0.0011	crab; human health English sole fillet and perch (using total seafood rate only); human health
Aroclor 1232	0.0020	na	na	0.00051-0.0033	0.00051-0.0031	0.00051-0.0011	crab; human health English sole fillet and perch (using total seafood rate only); human health
Aroclor 1242	0.0035	na	na	0.00051-0.0033	0.00051-0.0031	0.00051-0.0011	English sole fillet, perch, and crab; human health

Method and Analyte	MDL[a] (mg/kg ww)	ACGs (mg/kg ww)[b]					Sample type and receptor with ACG lower than MDL
		Sculpin Whole Body	English sole Whole Body	English Sole Fillet	Perch Whole Body	Crab Edible Meat[c]	
Aroclor 1248	0.00076	1.8	1.8	0.00051-0.0033	0.00051-0.0031	0.00051-0.0011	crab; human health English sole fillet and perch (using total seafood rate only); human health
Aroclor 1254	0.0015	0.53	0.53	0.00051-0.0033	0.00051-0.0031	0.00051-0.0011	crab; human health English sole fillet and perch (using total seafood rate only); human health
Aroclor 1260	0.0047	na	na	0.00051-0.0033	0.00051-0.0031	0.00051-0.0011	English sole fillet, perch, and crab; human health
EPA Method 1613B							
2,3,7,8-TCDD	4.0E-8	6.0E-6	6.0E-6	6.9E-09-4.5E-8	6.9E-09-4.2E-8	6.9E-9 - 1.5E-8	English sole fillet, perch, and crab for human health
EPA Method 1668A							
PCB-77	3.8E-7	0.0088	0.0088	6.8E-5 – 4.5E-4	6.8E-5 – 4.2E-4	6.8E-5 – 1.5E-4	
PCB-81	3.4E-7	0.0044	0.0044	6.8E-5 – 4.5E-4	6.8E-5 – 4.2E-4	6.8E-5 – 1.5E-4	
PCB-105	3.6E-7	0.06	0.06	6.8E-5 – 4.5E-4	6.8E-5 – 4.2E-4	6.8E-5- 1.5E-4	
PCB-114	3.3E-7	0.012	0.012	1.4E-5 - 8.9E-5	1.4E-5 - 8.4E-5	1.4E-5 - 3.0E-5	
PCB-118	4.0E-7	0.06	0.06	6.8E-5 - 4.5E-4	6.8E-5 - 4.2E-4	6.8E-5 - 1.5E-4	
PCB-123	6.8E-7	0.06	0.06	6.8E-5 - 4.5E-4	6.8E-5 - 4.2E-4	6.8E-5 - 1.5E-4	

Method and Analyte	MDL[a] (mg/kg ww)	ACGs (mg/kg ww)[b]					Sample type and receptor with ACG lower than MDL
		Sculpin Whole Body	English sole Whole Body	English Sole Fillet	Perch Whole Body	Crab Edible Meat[c]	
PCB-126	4.5×10^{-7}	0.00006	0.00006	6.8E-8 - 4.5E-7	6.8E-8 - 4.2E-7	6.8E-8 - 1.5E-7	English sole fillet, perch, and crab; human health
PCB-156	4.2×10^{-7}	0.012	0.012	1.4E-5 - 8.9E-5	1.4E-5 - 8.4E-5	1.4E-5 - 3.0E-5	
PCB-157	4.2×10^{-7}	0.012	0.012	1.4E-5 - 8.9E-5	1.4E-5 - 8.4E-5	1.4E-5 - 3.0E-5	
PCB-167	2.9×10^{-7}	0.6	0.6	6.8E-4 - 4.5E-3	6.8E-4 - 4.2E-3	6.8E-4 - 1.5E-3	
PCB-169	3.7×10^{-7}	0.0006	0.0006	6.8E-7 - 4.5E-6	6.8E-7 - 4.2E-6	6.8E-7 - 1.5E-6	
PCB-189	3.3×10^{-7}	0.06	0.06	6.8E-5 - 4.5E-4	6.8E-5 - 4.2E-4	6.8E-5 - 1.5E-4	
EPA Method 6020 (except as noted) [f]							
Antimony	0.020	9,082	9,082	0.033-0.21	0.033-0.20	0.033-0.069	
Arsenic	0.050	16	7.8	0.00069-0.0045	0.00069-0.0042	0.00069-0.0015	English sole fillet, perch, and crab; human health
Cadmium	0.010	21	17	0.087-0.57	0.087-0.54	0.087-0.19	
Chromium (EPA Method 6010)	0.50	34	34	0.25-1.6	0.25-1.5	0.25-0.53	English sole fillet, perch, and crab (using total seafood rate only); human health
Cobalt	0.0050	na	na	1.6-11	1.6-10	1.6-3.6	
Copper	0.060	108	62	3.3-21	3.3-20	3.3-6.9	
Lead	0.0040	34	34	na	na	na	
Molybdenum	0.0090	156	156	0.41-2.7	0.41-2.5	0.41-0.89	
Nickel	0.030	51	3.5	1.6-11	1.6-10	1.6-3.6	

Method and Analyte	MDL[a] (mg/kg ww)	ACGs (mg/kg ww)[b]					Sample type and receptor with ACG lower than MDL
		Sculpin Whole Body	English sole Whole Body	English Sole Fillet	Perch Whole Body	Crab Edible Meat[c]	
Selenium (EPA Method 7742)	1.0	0.57	0.57	0.41-2.7	0.41-2.5	0.41-0.89	crab; human health English sole fillet and perch (using total seafood rate only); human health crab and sculpin for river otter; English sole whole body
Silver	0.0040	na	na	0.41-2.7	0.41-2.5	0.41-0.89	
Thallium	0.0020	nd	nd	0.0055-0.036	0.0055-0.034	0.0055-0.012	
Vanadium	0.050	na	380	0.55-3.6	0.55-3.4	0.55-1.2	
Zinc	0.2	358	358	25-160	25-150	25-53	
EPA Method 1632							
Inorganic arsenic [g]	0.004	16	16	0.00069-0.0045	0.00069-0.0042	0.00069-0.0015	crab; human health English sole fillet and perch (using total seafood rate only); human health
EPA Method 7471							
Mercury	0.01	0.20	0.20	0.0083-0.054	0.0083-0.051	0.0083-0.018	English sole fillet, perch, and crab (using total seafood rate only); human health
TBT Method - Krone 1989							
Di-n-butyltin	0.00035	na	na	na	na	na	
Tri-n-butyltin	0.00033	0.26	0.26	0.012-0.078	0.012-0.073	0.012-0.026	
EPA Method 8081							
4,4'-DDD	0.00013	4.0	4.0	0.0042-0.027	0.0042-0.025	0.0042-0.0089	

Method and Analyte	MDL[a] (mg/kg ww)	ACGs (mg/kg ww)[b]					Sample type and receptor with ACG lower than MDL
		Sculpin Whole Body	English sole Whole Body	English Sole Fillet	Perch Whole Body	Crab Edible Meat[c]	
4,4'-DDE	0.00012	0.57	0.57	0.0030-0.020	0.0030-0.019	0.0030-0.0066	
4,4'-DDT	0.00038	4.0	4.0	0.0030-0.020	0.0030-0.019	0.0030-0.0066	
Total DDT	na	1.9	1.9	0.0030-0.020	0.0030-0.019	0.0030-0.0066	
Aldrin	0.0002	0.17	0.17	0.000059-0.00039	0.000059-0.00037	0.000059-0.00013	crab;human health English sole fillet and perch (using total seafood rate only); human health
alpha-BHC	0.00016	na	na	0.00016-0.0011	0.00016-0.0010	0.00016-0.00036	
beta-BHC	0.00021	35	35	0.00059-0.0039	0.00059-0.0037	0.00059-0.0013	
Chlordane	0.00036	1.1	1.1	0.0029-0.019	0.0029-0.018	0.0029-0.0063	
Dieldrin	0.00011	0.12	0.12	0.000064-0.00042	0.000064-0.00039	0.000064-0.00014	English sole fillet, perch, and crab (using total seafood rate only); human health
Endosulfan	0.00035	0.031	0.031	0.46-3.0	0.46-2.8	0.46-0.99	
Endosulfan sulfate	0.00027	nd	nd	na	na	na	
Endrin	0.000099	0.012	0.012	0.025-0.16	0.025-0.15	0.025-0.053	
gamma-BHC (Lindane)	0.00028	6.1	6.1	0.00078-0.0051	0.00078-0.0048	0.00078-0.0017	
Heptachlor	0.00045	1.5	1.5	0.00023-0.0015	0.00023-0.0014	0.00023-0.00050	English sole fillet, perch, and crab (using total seafood rate only); human health

Method and Analyte	MDL[a] (mg/kg ww)	ACGs (mg/kg ww)[b]					
		Sculpin Whole Body	English sole Whole Body	English Sole Fillet	Perch Whole Body	Crab Edible Meat[c]	Sample type and receptor with ACG lower than MDL
Heptachlor epoxide	0.00015	nd	nd	0.00011-0.00072	0.00011-0.00068	0.00011-0.00024	English sole fillet, perch, and crab (using total seafood rate only); human health
Hexachlorobenzene	0.0055	0.78	0.78	0.00064-0.0042	0.00064-0.0039	0.00064-0.0014	English sole fillet, perch, and crab; human health
Methoxychlor	0.00027	0.060	0.060	0.41-2.7	0.41-2.5	0.41-0.89	
Mirex	0.00027	1.4	1.4	0.016-0.11	0.016-0.10	0.016-0.040	
Toxaphene	0.0058	nd	nd	0.00097-0.0063	0.00097-0.0059	0.00097-0.0021	English sole fillet, perch, and crab (using total seafood rate only); human health

na – not available

nd – not determined

[a] MDLs from Columbia Analytical Services (Salata 2004a)

[b] ACGs for each tissue type are the lowest of the dietary or critical tissue residue RBCs associated with that tissue type. The ranges presented for English sole fillet, perch whole body and crab edible meat represent values calculated using a total seafood consumption rate (98 g/day), and values calculated using consumption rates for benthic fish (15 g/day), pelagic fish (16 g/day), and crab (45 g/day).

[c] ACG for edible meat tissue 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 MDL presented in the last column would not be affected.

[d] Not available for bird or mammal dietary RBCs and not determined for critical tissue residue RBC for fish

[e] This calculated MDL is the sum of the MDLs for individual PAHs

[f] Chromium and selenium cannot be analyzed by Method 6020 (ICP-MS) because of interferences.

[g] A subset of fish and crab tissue samples will be analyzed for both total and inorganic arsenic.

Table D-12. Tissue mass required per sample type

ANALYTE	TISSUE MASS (g) FOR CRAB[a]	TISSUE MASS (g) FOR FISH
PCB congeners and dioxins/furans	25	25
PCB Aroclors and organochlorine pesticides	20	20
SVOCs	10	10
PAHs (ultra low extraction)	10	10
Mercury	2	2
Other metals	2	2
Inorganic arsenic[b]	2	2
Tributyltin	2	10
Total Mass	**73**	**81**

na – not analyzed

[a] Separate tissue mass will be collected for edible meat and for hepatopancreas.

[b] Inorganic arsenic will be analyzed in a subset of samples.

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APPENDIX E. BACKGROUND APPROACH

E.1 INTRODUCTION

This appendix provides the problem definition, sampling design, schedule, and sample identification scheme for background sampling of fish, crab, and clam tissues and co-located sediment for arsenic. Sections E.2 and E.3 in this appendix provide equivalent types of information as Sections 2.2 and 3.1 in the QAPP, respectively. All other project elements discussed in the QAPP (i.e., field and analytical methods, QA/QC, data management) are applicable to the background sampling.

E.2 PROBLEM DEFINITION AND EXISTING INFORMATION

Phase 1 HHRA risk estimates for arsenic associated with seafood consumption were higher[19] than risk estimates for any other chemical (Windward 2003). The Phase 1 risk estimates did not discuss what percent of the risks could be attributable to the arsenic that occurs naturally in the Puget Sound basin or arsenic from anthropogenic sources outside the LDW. Elevated concentrations of arsenic can be found in sediments of central and northern Puget Sound as a result of natural geological features, such as volcanoes (Washington Department of Health 2002). The primary anthropogenic arsenic source outside the LDW is the former Asarco smelter, which operated in Ruston, Washington (near Tacoma) from the 1890s to 1986. Ecology is studying the impact of the smelter plume on the concentration of arsenic in soils downwind of the former smelter location (Ecology 2001). The highest arsenic concentrations in soils closely follow the prevailing wind patterns in the central Puget Sound basin. The wind blows from the southwest to the northeast (toward the LDW) about 60% of the time, and from the northeast to the southwest about 40% of the time (Figure E-1).

[19] Excess cancer risk estimates were as high in 1 in 1,000

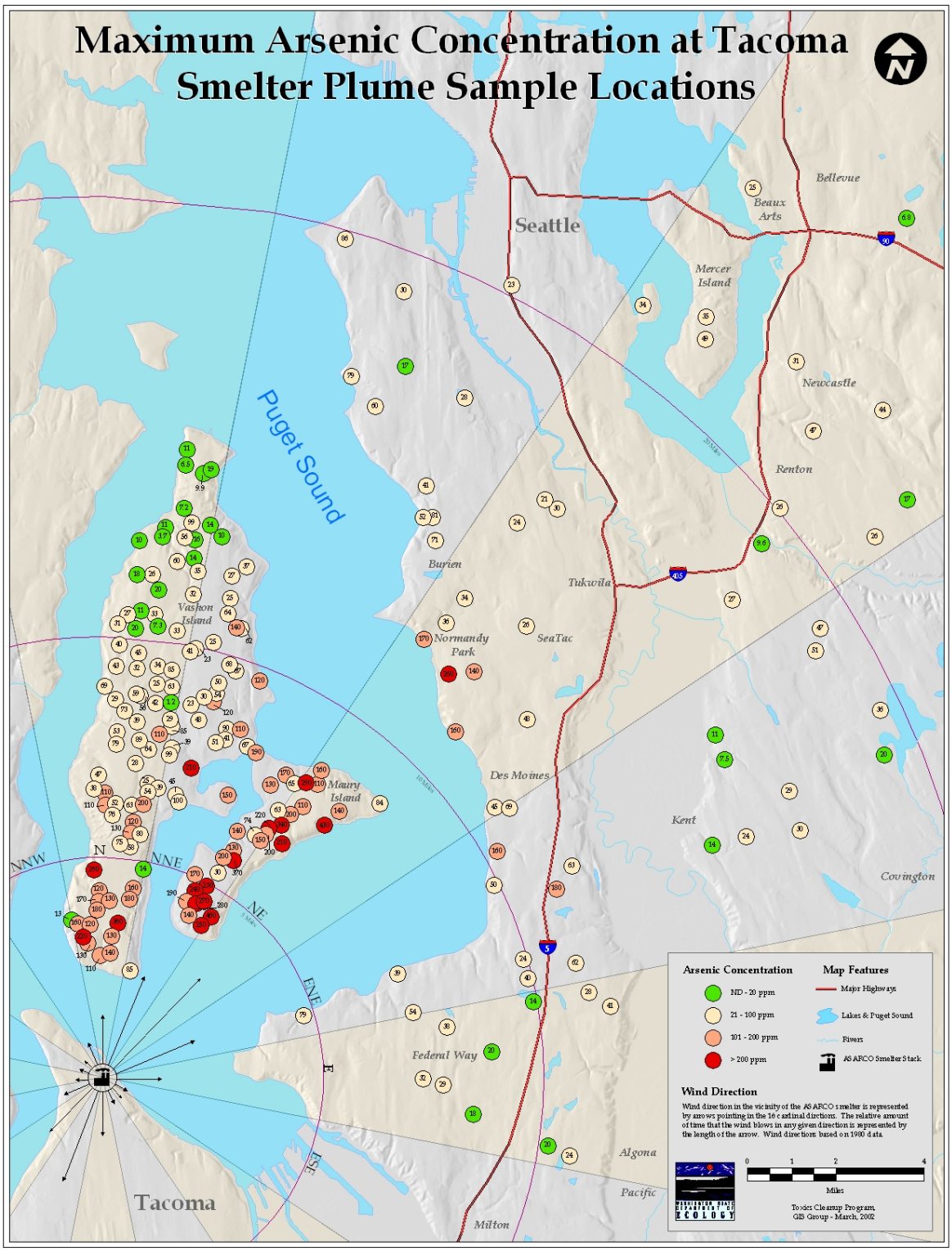


Figure E-1. Maximum soil arsenic concentrations at Tacoma smelter plume locations

It is not clear whether arsenic concentrations in LDW seafood are different from arsenic concentrations in seafood outside the LDW. During Phase 2, risks attributable to background arsenic will be considered during the risk characterization phase following EPA (2002b) guidance. Therefore, additional data for arsenic concentrations in seafood outside of the LDW are needed from an area representing naturally occurring arsenic in the Puget Sound basin and from an area that may have been affected by the smelter to a similar extent as the LDW basin soils.

In the Phase 1 HHRA, exposure to arsenic through seafood ingestion was estimated based on concentrations of total arsenic in English sole, crabs, and mussels collected in the LDW. Perch were also evaluated in the Phase 1 HHRA, but no arsenic data were available for the LDW perch fillets. Clams were not evaluated in Phase 1; however, clams will be added to the seafood market basket for Phase 2 because clams were found in sufficient abundance during the clam survey conducted in August 2003 (Windward 2004). In the Phase 2 HHRA, arsenic risks will be evaluated based on consumption of English sole, perch, clams, crabs, and mussels.

The arsenic toxicity values promulgated by EPA for the protection of human health are based on the toxicity of inorganic arsenic rather than total arsenic. For the Phase 1 HHRA, only total arsenic data were available for seafood, so a conversion factor was applied to the total arsenic data from the LDW to estimate inorganic arsenic concentrations before making risk estimates. At the direction of EPA Region 10 staff, Phase 1 risk estimates for arsenic were based on the assumption that 10% of the total arsenic was inorganic arsenic, the most toxic arsenic species. This assumption may be an overestimate of the true fraction of inorganic arsenic in seafood. In Phase 2, inorganic arsenic will be analyzed in tissues of seafood organisms, making the 10% assumption unnecessary.

Inorganic arsenic has not been analyzed in LDW tissue samples and has been infrequently analyzed in Puget Sound tissue samples. Ecology (2002) conducted a study of inorganic arsenic in English sole, clams, and crabs from several urban bays, but quality control concerns (e.g., holding time exceedances) make these data unsuitable for use in the Phase 2 RI. Therefore, concentrations of total and inorganic arsenic in tissue samples are needed from background locations, both inside and outside the area influenced by the Asarco smelter plume. Two background location types are appropriate because arsenic concentrations may be different between the two environments and EPA (2002b) policy acknowledges that both natural and anthropogenic sources may be relevant as background for risk characterization. The collection of these data is discussed in Section E.3.

Based on the review of existing information, background data for arsenic concentrations in fish tissues (i.e., English sole fillets and shiner surfperch), clams, and crabs need to be collected both from a background area representing naturally occurring arsenic in the Puget Sound basin and from an area that may have been

affected by the smelter to a similar extent as the LDW. Total and inorganic arsenic data from a background location are not needed for mussels because the assumed consumption rate associated with mussels is low (i.e., less than 10% of the overall seafood consumption rate used in the Phase 1 HHRA), and the total arsenic concentrations in mussels are much lower than total arsenic concentrations in other LDW species.[20] Consequently, the effort associated with background sampling for mussels is not warranted because the resulting data would likely have little impact on the overall seafood consumption risk estimate.

Thus, the primary objective for the background sampling is to acquire data on total and inorganic arsenic concentrations in fish, crabs, and clams and co-located sediment[21] collected from a background area representing naturally occurring arsenic and from a background area representing primary anthropogenic sources (i.e., former Asarco smelter) outside of the LDW for comparison with total and inorganic arsenic concentrations in fish collected from the LDW. The results of these comparisons will be used to more fully characterize the risks potentially attributable to site-specific arsenic sources, if any, in LDW seafood.

E.3 SAMPLING DESIGN AND METHODS

E.3.1 Selection of background locations

As discussed above, samples of English sole (fillets), shiner surfperch (whole body), crabs, and clams will be collected from two background locations and analyzed for total and inorganic arsenic. An ideal background location would have the same physical, chemical, geological, and biological characteristics as the LDW, but would not be affected by historical or current activities in the LDW (EPA 2002a). As acknowledged by EPA (2002a), such an ideal location is typically not available. Instead, background locations were selected based on the following criteria:

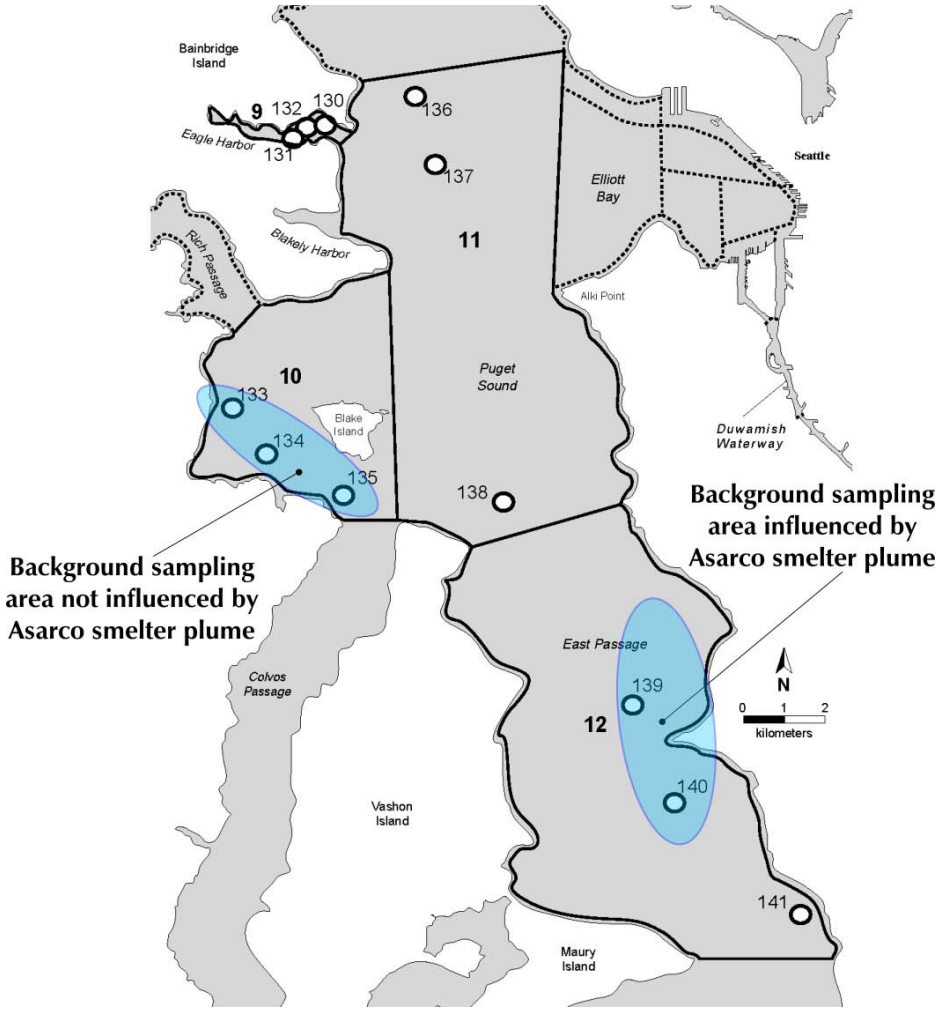
- the location must be relatively near the LDW to maximize the likelihood that physical, chemical, and geological characteristics will be similar to the LDW
- the target species for the HHRA must be available from this location
- the location must be characterized with respect to the concentration of arsenic in sediment and be located away from local arsenic sources

As a component of a three-year cooperative effort by NOAA and Ecology, surface sediments from 100 locations in central Puget Sound were analyzed in 1998 to

[20] The maximum total arsenic concentration in LDW mussels was 1.07 mg/kg ww, which is more than an order of magnitude lower than the maximum total arsenic concentration detected in LDW English sole fillets (Windward 2003).

[21] Note that co-located sediment will be collected as part of this QAPP to verify exposure conditions in background locations where tissue are being collected; additional sediment will be collected upstream of the LDW as part of the surface sediment QAPP to assess background concentrations of arsenic in sediment.

determine sediment quality (NOAA and Ecology 2000). The locations included major urban centers (e.g., Seattle and Bremerton) and marine waters adjacent to less developed areas. Thirty-three locations in Elliott Bay, West Waterway, and East Waterway were sampled during this event. These locations are near the LDW and the target species are available from these areas, but it is not known whether local arsenic sources in this highly urbanized area contribute arsenic to these environments. Consequently, less urbanized areas were selected as background sampling locations, one within the assumed Asarco smelter plume and one outside the smelter plume (Figure E-2).



Source: NOAA and Ecology (2000)

Figure E-2. Background sampling areas

Several locations were sampled by NOAA and Ecology in 1998 in central Puget Sound, including both west and southwest of Seattle. Stratum[22] 10 (west of Blake Island;

[22] Stratum refers to the subarea assessed in the stratified random sampling design of the study.

locations 133, 134, and 135 in Figure E-2) is not likely to have been influenced by the Asarco smelter plume given the prevailing wind patterns shown in Figure E.1. Stratum 12 (East Passage; locations 139, 140, and 141 in Figure E-2) is within the smelter plume. The northern portion of stratum 12 (locations 139 and 140) is directly between the former smelter location (see Figure E-1) and the LDW. Both strata 10 and 12 are relatively close to the LDW. The target species are likely to be found in both these areas because they are commonly found in nearshore Puget Sound environments, although the abundance of shiner surfperch may be patchy and variable from year to year (Eaton 2004).

Total arsenic was analyzed in sediments collected at each location in 1998 (NOAA and Ecology 2000)(Table E-1). The arsenic concentrations in Stratum 10 were all below the 6.49 mg/kg dw median concentration reported from central Puget Sound locations sampled in 1998 (NOAA and Ecology 2000), supporting the hypothesis that this area was not influenced by the former Asarco smelter plume. These concentrations are also lower than 95% of the arsenic concentrations measured in LDW surface sediment, and lower than both the arithmetic (13 mg/kg dw) and spatially-weighted (12 mg/kg dw) mean arsenic concentrations in the LDW. Total arsenic concentrations in the northern portion of Stratum 12 (East Passage) are higher than the median arsenic concentration in central Puget Sound, higher than the arsenic concentrations in Stratum 10, and slightly lower than mean concentration in the LDW. These data support the hypothesis that this area may have been influenced by the former Asarco smelter plume to some degree.

Table E-1. Total arsenic sediment concentrations and other physical characteristics at select central Puget Sound sampling locations

Stratum	Sample Number	Water Depth (m)	Total arsenic Concentration (mg/kg dw)	Substrate Description	Percent Fine Substrate (Silt + Clay)
10	133	26.4	5.19	sand, shells	19
10	134	44.8	4.65	sand	13
10	135	37.5	4.55	sand, plant fragments	11
12	139	232.5	8.82	silt-clay	54
12	140	188.7	10.4	silt-clay	98
12	141	96.4	6.36	cobbles, gravel, sand	12

Source: NOAA and Ecology (2000)

Although sediment total arsenic concentrations are a relevant descriptor of environmental exposure, aquatic organisms can also potentially accumulate arsenic from the water column. Based on available data, arsenic concentrations in surface water do not vary greatly by location. Total arsenic was analyzed in 264 water samples collected from the LDW in 1996 and 1997 during King County's Water Quality Assessment (King County 1999). The mean and maximum total arsenic concentrations were 0.83 and 1.5 µg/L, respectively. King County also conducts monitoring for metals

in water samples in central Puget Sound as part of their assessment of environmental conditions in the vicinity of wastewater treatment plant outfalls. During 1999 and 2000, monthly monitoring was conducted near two outfalls (West Point and Renton) and at several background locations (Admiralty Inlet, Possession Sound, Point Wells, Jefferson Head, Fauntleroy/Vashon, and Colvos Passage) (King County 2001). The mean (1.1 µg/L) and maximum (1.2-1.4 µg/L) total arsenic concentrations at all eight locations were virtually identical to each other, and similar to the concentrations in the LDW. Colvos Passage, shown in Figure E-2, is relatively close to both background sampling areas. Based on these data, there is no reason to believe that arsenic water concentrations at the background sampling areas are any different than the arsenic water concentrations in the LDW or at other locations where samples were collected and analyzed by King County in central Puget Sound.

Given the arsenic concentrations in the sediment in the vicinity of Blake Island and East Passage (Table E-1), fish, crabs, and clams collected from these areas are likely to have been exposed to similar or lower arsenic concentrations in sediment than fish, crabs, and clams found in the LDW. Also, arsenic concentrations in surface waters in the vicinity of these background areas are likely similar to arsenic concentrations in LDW and other central Puget Sound surface waters. Based on the available arsenic data in sediment and water, the Blake Island and East Passage areas should be suitable background locations for fish, crabs, and clams. Sediment will be collected in these areas as part of this sampling event to verify the arsenic concentrations in sediment. The selection of specific background beaches for clam collection in the Blake Island and East Passage areas will be determined in consultation with EPA and Ecology, and will be based on intertidal areas with suitable clam habitat with no apparent potential local arsenic sources.

E.3.2 Schedule

The LDW sampling schedule described in Section 2.3 of the fish and crab tissue QAPP includes sampling in early August 2004 and sampling from August 30 to September 10, 2004. Collection of surfperch sampling is the focus of the earlier sampling event because existing data suggest adult surfperch are not present in the LDW during September, presumably because they have moved to deeper waters in Elliott Bay or elsewhere. The migratory trend noted in the LDW for adult shiner surfperch is not likely to occur in the deeper waters at the background sampling areas (Table E-1), so there is no reason to conduct shiner surfperch sampling at a different time than sampling for the other species in background areas.

The sampling of both background areas will occur in the latter two weeks of September 2004, after the LDW sampling has been completed. Tiering the background sampling in this fashion maximizes the likelihood that the study design implemented in the LDW (i.e., target species, size of fish, number of organisms per composite sample) can be matched in the background sampling areas.

E.3.3 Sampling methods

Six composite tissue samples each of English sole (whole body and fillets), shiner surfperch (whole body), crabs (edible meat), and clams will be collected from each background area. Each fish and crab composite sample will consist of five organisms, and each clam composite sample will consist of at least 20 clams (each larger than 2 cm).[23] These numbers are consistent with the numbers of composite samples and organisms per composite sample being collected in each sampling area in the LDW, and meet minimum data requirements for calculating a 95% UCL on the mean concentration. The arsenic data sets will be evaluated in the risk assessments using an incremental risk approach,[24] but one-tailed *t*-tests for significant differences will also be conducted to compare the data sets. Use of the identical study design components for sample numbers and organisms per composite will facilitate comparison of the LDW and background data sets.

Fish will be collected using a high-rise otter trawl and crabs will be collected with crab traps following the same methods to be used in the LDW (see Section 3.2 of the QAPP). Clam collection will follow the same methods outlined in the benthic invertebrate QAPP, including the collection of co-located sediment (Section 3.2.6 of the benthic invertebrate QAPP, Windward 2004c).

The trawl locations (starting point, compass heading, and path) will be at the discretion of the boat captain, who will decide where to sample based on the likelihood of collecting the target species because there is no reason to believe that sediment arsenic concentrations in these background areas are spatially heterogeneous. At the East Passage background area, trawling will be conducted in the nearshore environments at water depths much shallower than the > 180 m water depths observed at sample locations 139 and 140 (Table E-1). Trawling will continue until target numbers of each species are obtained or for a maximum of two days of sampling at each background area. In the event that insufficient numbers of fish can be obtained in two days from a given area, alternative background areas may be sampled. Crab traps will be placed randomly in the areas trawled at each of the background locations according to the methods outlined in Sections 3.2.2.4 and 3.2.3.2. Specific clam sampling areas at each background location will be determined in consultation with EPA and Ecology, and will be selected in the field based on the availability of intertidal areas with suitable clam habitat and no apparent potential local sources.

LDWG will discuss alternative background sampling areas with EPA and Ecology in the event they are needed. Sampling handling, processing, and analysis methods will be identical to those described in Sections 3.2, 3.3, and 3.4 in the fish and crab tissue

[23] If more than 5 fish or crabs per composite sample are collected in the LDW, a similar number of fish or crabs per composite will be targeted at the background areas, within the level-of-effort constraints described in the text.

[24] The incremental risk approach focuses on the differences between risk estimates made for exposure within the LDW compared to exposure in background areas outside the LDW.

QAPP. All background tissue samples will be analyzed for total and inorganic arsenic, lipids, and moisture content.

A total of one sediment composite sample will be collected at each of the trawling locations. The composite sample will consist of sediment from a total of five grabs, homogenized on the boat. Sediment will be analyzed for total arsenic only, thus 250 mL is needed.

This sediment sample will be collected using a van Veen grab sampler as described in the following steps:

1. Maneuver the sampling vessel to the pre-identified sampling location (within 1-2 m of the intended station) using GPS.
2. Open the grab sampler jaws into the deployment position.
3. Guide the sampler overboard until it is clear of the vessel.
4. Lower the sampler through the water column to the bottom at approximately 0.3 m/s.
5. Record the GPS location of the boat when the sampler reaches bottom.
6. Retrieve the sampler and raise it at approximately 0.3 m/s.
7. Guide the sampler aboard the vessel and place it on the work stand on the deck, using care to avoid jostling that might disturb the integrity of the sample.
8. Examine the sample using the following sediment acceptance criteria:
    - Sediment is not extruded from the upper face of the sampler such that organisms may have been lost.
    - Overlying water is present (indicating minimal leakage).
    - The sediment surface is relatively flat (indicating minimal disturbance or winnowing).
    - The entire surface of the sample is included in the sampler.
    - The following penetration depths are achieved at a minimum:

        4-5 cm for medium-coarse sand

        6-7 cm for fine sand

        ≥ 10 cm for muddy sediment

If these sample acceptance criteria are not achieved, the sample will be rejected.

After sample acceptance, the following observations will be noted in the field logbook:

- station GPS location
- depth as read by the boat's depth sounder

- gross characteristics of the surficial sediment including texture, color, biological structures, odor, and presence of debris and oily sheen
- gross characteristics of the vertical profile (i.e., changes in sediment characteristics and redox layer, if visible)
- maximum penetration depth (nearest 0.5 cm)
- comments relative to sample quality

A sediment sample will also be collected with each of the six clam composite samples collected at each of two background locations. At each clam tissue collection location, 50 mL of the first shovelful of sediment will be collected for analysis of total arsenic. A minimum of five 50-mL sediment subsamples will be composited into each 250 mL sediment sample per location. The volume of collected sediment will be estimated using a 50-mL beaker, and the sediment samples will be collected to a depth of 10 cm.

A total of 14 sediment samples will be collected at background locations. Arsenic will be analyzed in sediment samples at Columbia Analytical using EPA Method 6020. Samples will be homogenized in the field, stored in glass jars, kept in a cooler with wet ice, and shipped within one day of collection to the laboratory with chain-of-custody forms. Data quality indicators for this sample include 30% precision and 70-130% accuracy. The method detection limit is 0.2 mg/kd dw. Quality control procedures will be implemented as described in Section 3.5 of the QAPP.

E.3.4 Sample identification

Unique alphanumeric identification (ID) numbers will be assigned to each individually wrapped specimen in the field. The first two characters will be BL (for Blake Island) or EP (for East Passage). The next characters will identify the individual species type: ES, SS, CL, and DC representing English sole, shiner surfperch, clam, and Dungeness crab. Alternative species, if they are collected, will be identified with SF, SP, PP, SC, and RC for starry flounder, striped perch, pile perch, slender crab, and red rock crab, respectively. Alternative species would only be collected in background areas if composite samples of these are created for the LDW.

The final identifier will be numeric and indicate the sequential number of the specimen captured for a given background sampling area. As an example, the eleventh English sole captured in the Blake Island area would be identified as BL-ES-11. All relevant information (including specimen ID, length, weight, sex [if it can be determined without dissection], sample date, time, and location number) for each individually wrapped and labeled target specimen will be recorded on the fish and crab tissue collection form (Appendix B) and included as an appendix in the final data report(s). Therefore, all pertinent data associated with each individual fish specimen can be tracked.

Composite samples will be identified using a similar convention, with two additions: tissue type will be indicated as WB for whole-body (English sole and shiner surfperch), FL for skin-on fillet (English sole) or EM for edible meat (crab). Each sample for a given species and background area combination will be numbered sequentially following the letters "comp." For example, the second whole-body composite shiner surfperch sample from the East Passage area would be identified as EP-SS-WB-comp2.

For sediment samples, unique alphanumeric identification (ID) numbers will be assigned to each composite sample collected in the field. The first two characters will be BL (for Blake Island) or EP (for East Passage). The next characters will be S for sediment followed by TR for samples associated with trawling or CS for samples associated with clam sampling. The final identifier will be numeric and indicate the associated clam sample. As an example, the sediment sample collected in the Blake Island area with the fifth clam sample would be identified as BL-S–CS-5.

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