HYLEBOS FISH INJURY STUDY
Round II

Part 3: Exposure of juvenile chinook salmon to chemical contaminants specific to the Hylebos Waterway: Tissue concentrations and biochemical responses.

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EXECUTIVE SUMMARY

The Hylebos Waterway of Commencement Bay, an urban estuary in central Puget Sound, Washington, is severely contaminated with a variety of organic and inorganic chemicals. Juvenile salmon inhabit this waterway in the late spring and early summer during their migration from fresh water to the open ocean. Studies conducted in 1989 and 1990 revealed that juvenile chinook salmon migrating through Commencement Bay had elevated concentrations of polycyclic aromatic hydrocarbons (PAHs) and chlorinated hydrocarbons (CHs) or their derivatives in tissues, bile and stomach contents, and that they exhibited biochemical changes indicative of contaminant exposure. Round I of the Hylebos Fish Injury Study, conducted in 1994 and 1995, showed that both juvenile chum and chinook salmon sampled from the Hylebos Waterway were also exposed to a wide range of chemical contaminants (Collier et al. 1998). Furthermore, the levels of exposure and biochemical responses were comparable to levels that have previously been associated with impaired growth, immunosuppression, and increased mortality following pathogen exposure in juvenile salmon; biological effects that can have significant population impacts. Whether juvenile salmon exposed in the laboratory to anthropogenic chemical contaminants specific to the Hylebos Waterway would exhibit similar chemical and biochemical changes was unknown.

In 1996, Round II of the Hylebos Fish Injury Study continued with laboratory experiments designed to establish links between chemical exposure and injury as well as quantify the extent of the injury. Results of the first two laboratory experiments (disease challenge and growth) in Round II (see SAP, Appendix 1) show that juvenile salmon exposed to PCBs, PAHs, HCBD, and organic-solvent extracts of sediments from the Hylebos Waterway exhibit increased disease susceptibility (altered immunocompetence) (Part 1 of Round II Hylebos Fish Injury Study) and reduced growth (Part 2 of Round II Hylebos Fish Injury Study). Within the scope of Round II studies, we needed to further identify the chemical contaminants potentially responsible for causing injury and examine the persistence of chemical contaminants and biochemical responses which were measured in Round I.

The objectives of the present laboratory study (Part 3 of Round II Hylebos Fish Injury Study) were to determine: 1) classes of chemical compounds that produce alterations in chemical and biochemical measures of contaminant exposure in juvenile salmon tissues, 2) the persistence of chemicals in the tissues of exposed fish, and 3) the magnitude and persistence of biochemical responses as a result of exposure to chemical compounds characteristic of the Hylebos Waterway. To accomplish these objectives, juvenile salmon were injected intraperitoneally (i.p.) with a single dose of either 1) hexachlorobutadiene (HCBD), a signature compound of the Hylebos Waterway, 2) an extract made from Hylebos Waterway sediment using methylene

chloride as the extracting solvent (HWSE-M), 3) an extract made from Hylebos Waterway sediment using pentane as the extracting solvent (HWSE-P), 4) a model mixture composed of 10 high-molecular weight polycyclic aromatic hydrocarbons (PAHs) proportional to their concentrations in a sediment sample from the Hylebos Waterway, 5) the PCB mixture, Aroclor 1254, 6) a reference sediment extract made from Nisqually River estuary sediment (NQSE) using methylene chloride as the extracting solvent, or 7) acetone/Emulphor (A/E), the solvent vehicle. Bile, liver, and gutted-whole body were collected at different intervals up to 60 d post exposure and analyzed for chemical exposure including tissue concentrations of CHs (e.g., HCBD, chlorinated pesticides and PCBs); as well as biochemical responses including biliary levels of fluorescent aromatic compounds (FACs), hepatic cytochrome P4501A-dependent monooxygenase activity (CYP1A) and hepatic DNA adduct levels.

Results from this portion of the study (Part 3) conducted in Round II of the Hylebos Fish Injury Study showed that: 1) PCBs and PAHs induced alterations in chemical and biochemical measures of exposure in juvenile salmon after single-dose injection, 2) PCBs, cytochrome P4501A induction and PAH-DNA adducts persisted for up to 60 days in the tissues of exposed animals after single-injection exposure, 3) HCBD exposure resulted in increased tissue concentrations, but did not induce, as expected, any biochemical response at the tissue levels of exposure used in this laboratory study, and 4) the tissue levels of PCBs, HCBD, and the biochemical responses in juvenile salmon treated with the Hylebos sediment extracts were comparable to the levels and responses observed in salmon sampled directly from the Hylebos Waterway in Round I (Collier et al. 1998). These findings, in conjunction with the findings from the first two laboratory experiments of Round II [showing impaired disease resistance (Part 1) as well as impaired growth (Part 2) in juvenile salmon exposed to the same Hylebos sediment extracts], support the conclusion that juvenile salmon residing in the Hylebos Waterway will likely exhibit impaired growth and increased disease susceptibility as a result of their dependence on this contaminated habitat.

INTRODUCTION

Estuaries are important habitats for several Pacific salmonid species (*Oncorhynchus* spp.), including the fall-spawning chinook which use estuaries as juvenile rearing habitat (Thorpe 1994). The estuary acts as an intermediate environment for their physiological adaptation to ocean conditions, a profitable foraging ground and a refuge from predators. Results from recent studies of juvenile chinook salmon (*Oncorhynchus tshawytscha*) captured from the Duwamish Waterway, a highly contaminated urban estuary in Puget Sound, consistently showed elevated exposure to polycyclic aromatic hydrocarbons (PAHs) and chlorinated hydrocarbons (CHs) when compared to juvenile chinook salmon captured from the Nisqually River Estuary, a minimally contaminated non-urban area (McCain et al. 1990, Collier et al. 1998). Moreover, increased exposure to these chemical contaminants led to induction of cytochrome P4501A (CYP1A) enzyme activities and damage to hepatic DNA in juvenile chinook salmon as they migrated through the contaminated estuarine environments of the Duwamish Waterway as well as Commencement Bay in Puget Sound, Washington (Stein et al. 1995).

In Round I of the Hylebos Waterway Fish Injury Assessment, juvenile chum (*Oncorhynchus keta*) and chinook salmon from the Hylebos Waterway showed elevated PAH metabolites in bile and CHs in liver which were comparable to those found in juvenile chinook salmon from the Duwamish Waterway (Collier et al. 1998). Furthermore, the levels of exposure were similar to those associated with impaired growth, immunosuppression, and increased mortality following pathogen exposure in chinook salmon collected from the Duwamish Waterway (Arkoosh et al. 1991, Casillas et al. 1995a). In addition, juvenile chum and chinook from the Hylebos Waterway had concentrations of hexachlorobutadiene (HCBD) in the liver that exceeded those found in any of our previous field studies with salmon (Varanasi et al. 1993). Associated with these increased concentrations of chemicals were indications of early biological alterations and damage, as shown by increases in hepatic CYP1A-associated enzyme activity and increased levels of DNA adducts (Collier et al. 1998). Increases in both of these measures are well established as being linked to contaminant exposure (Collier and Varanasi 1991, Varanasi et al. 1992, Stein et al. 1992). DNA adducts represent reversible damage to genetic material that has been shown to be associated with hepatic lesions in fish (Myers et al. 1998). In the present study DNA adducts were used as an indicator of exposure to genotoxic polycyclic aromatic compounds based on our previous studies (French et al. 1996, Stein et al. 1992, 1994). However, from the findings in Round I, it was not clear which classes of contaminants found in the Hylebos Waterway contributed to these biological alterations; nor was it clear how long elevated body levels of contaminants or biochemical alterations would persist after fish moved out of the contaminated estuary and into marine waters.

The objective of the present laboratory study was to assess the time-responsiveness of tissue CHs, biliary FACs, hepatic CYP1A, and hepatic DNA adducts (measured in Round I) in juvenile chinook salmon exposed to contaminants specific to the Hylebos Waterway and sampled for up to 60 days following a single exposure. Specifically in July 1997, juvenile chinook salmon from a local hatchery were injected intraperitoneally (i.p.) with: 1) hexachlorobutadiene (HCBD), a signature compound of the Hylebos Waterway, 2) an extract made from Hylebos Waterway sediment using methylene chloride as the extracting solvent (HWSE-M), 3) an extract made from Hylebos Waterway sediment using pentane as the extracting solvent (HWSE-P), 4) a model mixture composed of 10 high-molecular weight polycyclic aromatic hydrocarbons (PAHs) proportional to their concentrations in a sediment sample from the Hylebos Waterway, 5) the PCB mixture, Aroclor 1254, 6) a reference sediment extract made from Nisqually River estuary sediment (NQSE) using methylene chloride as the extracting solvent, or 7) acetone/Emulphor (A/E), the solvent vehicle. The results from this study will provide a basis for evaluation of the relationship between the level of exposure to chemical contaminants specific to the Hylebos Waterway and the significant biological effects observed in juvenile chinook salmon in the previous laboratory studies, and will also allow for comparison to the results obtained for juvenile chinook salmon sampled directly from the Hylebos Waterway in Round I.

METHODS

Details of the experimental design and methods used in the present study are described in the addendum to the SAP (Appendix 1). The chemical compositions of the NQSE, HWSE-M, HWSE-P sediment extracts and their concentrations are listed in Table 1, 2, and 3, respectively. The composition of the PAH model mixture is listed in Table 4.

Exposure Dosage Assessment

All fish were injected intraperitoneally (i.p.) with PAH model mixture, HCBD, PCB mixture (Aroclor 1254), sediment extracts from the Hylebos Waterway or the Nisqually River estuary mixed with the solvent vehicle, acetone:Emulphor (1:1, v/v), or the solvent vehicle alone. The objective of administering HWSE-M, HWSE-P, a model mixture of PAHs, Aroclor 1254, and HCBD was to expose juvenile salmon to known quantities of compounds representative of chemical contaminants present in the sediment from the Hylebos Waterway.

The Nisqually River estuary sediment extract (NQSE) was prepared from sediment collected near the mouth of the Nisqually River. The chemical profile in this extract is representative of sediment from a non-urban site that is minimally contaminated (Table 1). The NQSE sediment extract was prepared using methylene chloride as the extracting solvent. The injection dosage for this extract was 200 g sediment extracted/ kg fish which is equivalent to administering 0.005 mg ΣAHs/kg fish, 0.0004 mg ΣPCB/kg fish, and < 0.001 μg HCBD/kg fish. Juvenile chinook salmon treated with NQSE served as a control group for the Hylebos sediment extract treated fish, providing a more appropriate control group to assess the influence of Hylebos-associated contaminated sediment extracts on the chemical and biochemical parameters measured in juvenile chinook salmon.

The Hylebos Waterway sediment extracts (HWSE-M and HWSE-P) were prepared from sediment collected near the mouth of the Hylebos Waterway from Stations HY-07, -08, and -09, as designated during the sediment injury studies conducted during Round I of the Hylebos Damage Assessment investigations. (see Appendix D in Collier et al., 1998). These sediment extracts were prepared using two different solvents to obtain test solutions that included specific chemical compounds present in sediment from the Hylebos Waterway. The composition of analytes in the two Hylebos Waterway extracts is listed in Tables 2 and 3. The HWSE-M sediment extract was prepared using methylene chloride as the extracting solvent. The chemicals present in the HWSE-M represent the full range of chemicals (AHs and CHs) that may be available to fish. The HWSE-P extract was prepared using pentane to reduce the proportion of high-molecular weight AHs (HMWAHs) extracted, thereby increasing the concentration of CHs relative to HMWAHs. Some CHs present in the HWSE-P were partly removed in this

preparation, but to a lesser degree than the PAHs. The HWSE-M was administered at a dose of 200 g sediment extracted/kg fish which is equivalent to 0.35 mg ΣPAHs/kg fish, 0.032 mg ΣPCBs/kg fish, and 0.038 mg HCBD/kg fish; whereas, the HWSE-P extract was administered at a dosage of 400 g sediment extracted/kg fish which is equivalent to 0.24 mg ΣPAHs/kg fish, 0.028 mg ΣPCBs/kg fish, and 0.045 mg HCBD/kg fish. A dose equivalent to 400 g of HWSE-P sediment extracted/kg fish was used so that the levels of measured chemical contaminant administered for the two Hylebos sediment extracts would be comparable.

A model mixture of polycyclic aromatic hydrocarbons (PAHs) containing 10 high-molecular weight PAHs was prepared to reflect the same ratios of these analytes as previously found in sediment sampled during Round I of the Hylebos Damage Assessment studies at Station HY-24 (Appendix D, Collier et al. 1998). The PAH model mixture in acetone/Emulphor was administered at a dosage of 6.3 mg ΣPAHs/kg fish. The effect of PCBs was evaluated using a commercial mixture (Aroclor 1254). The PCB mixture prepared in acetone/Emulphor was administered at a dosage of 28 mg ΣPCBs/kg fish. The HCBD solution prepared in acetone/Emulphor was administered at a dosage of 21 mg HCBD/kg fish. All test solutions, including controls, were each administered at a volume equivalent to 1.5 µl solution/g fish.

Experimental conditions, mortality and sampling strategies

Ambient water temperatures during the course of the study ranged from 11.6°C at 0 d to 12.8 °C at 60 d post exposure (Casillas et al. 1998). The mean (± SD) water temperature was 12.2± 0.4 °C. Temperature was kept relatively constant by drawing seawater from a depth of approximately 50 feet, thereby minimizing the influence of more rapid changes in surface-seawater temperatures.

Fish were fed to satiation twice a day, once in the morning and once in the afternoon with food pellets (Biodry 1000, Bioproducts).

Recorded mortalities of experimental fish ranged from 6% to 19% (18 to 53 animals) for each of the treatment groups (300 fish per group) during the experimental period (Table 5). The highest number of mortalities was observed in juveniles receiving either the HWSE-M or the PCB formulation (Aroclor 1254). In contrast, the lowest mortalities were observed in juveniles receiving the solvent vehicle (acetone/Emulphor). With the exception of HWSE-P, HCBD, and PCB treated groups, mortalities were low and stable in the second half of the experimental period (Table 5). During the course of the experiment, we could not account for approximately 12% of the injected fish and we assume that these fish either escaped from the tanks through the exiting water standpipe, or gaps in the tank covers (Appendix 3). Exposed fish from all 7 treatments were sampled at 6 d and 20 d post exposure; but shortly after that it became apparent that insufficient numbers of fish would be available for the 60 d sampling time-point. Hence, the

HWSE-M and NQSE treated groups were sampled at 33 d post exposure. the solvent vehicle group was sampled at 35 d post exposure, and the HCBD and HWSE-P groups were sampled at 56 d post exposure. The PAH and PCB groups were sampled at 62 d post exposure. All three biochemical parameters were analyzed from all samples collected, except for chemical concentrations in tissues where only samples collected at 6 d, 20 d from the time-response study and samples collected at 60 d from the growth study were analyzed. To compensate for the treatment groups that could not be carried out to the full 60 d in this experiment, appropriate samples of fish which received the same exposure were collected from the growth experiment, conducted simultaneously with the biomarker experiment (Casillas et al, 1998). Therefore, the results presented in this report were of samples from all seven treatments collected at 6 d and 20 d post exposure from the biomarker study, and 60 d post exposure from the growth study.

Prior to analysis, samples were composited to obtain sufficient tissue and fluid for the biochemical and chemical analyses. Liver and bile from 20 individual fish were composited for biochemical analyses such as PAH metabolites in bile, hepatic CYP1A activity, and levels of hepatic DNA adducts. For chemical analyses of CHs in whole body tissues, five individual gutted whole bodies were composited. At each time point, three composites of bile, livers, and whole gutted bodies were collected per treatment. Composited liver samples were flash-frozen in liquid nitrogen and subsequently stored at -80°C until analysis. Composited bile and whole body samples were kept on ice and subsequently stored at -20°C until analysis.

Statistical methods

Statistical significance of the biomarker responses at 6, 20, and 60 d post exposure was assessed using ANOVA (Super ANOVA, Abacus Concepts Inc., Berkeley, CA, 1989). Significance of results of treatment groups compared to the control groups of fish (fish receiving acetone/Emulphor or the reference Nisqually River estuary sediment extract) was evaluated using Dunnett's Multiple Comparison Test (Zar 1978) at $\alpha = 0.05$ for each variable independently.

RESULTS

Sediment Extract Chemistry

In this study, two different extraction methods were used to isolate non-polar toxic CHs and AHs (polar compounds were removed from the extracts) from a representative Hylebos Waterway sediment. The major difference in these methods was the solvent used in the extraction process (pentane or methylene chloride). In the pentane extract of the Hylebos Waterway sediment (HWSE-P), the proportion of high-molecular weight AHs (HMWAHs) was reduced relative to the CHs; therefore, the ratio of CHs to HMWAHs was increased from a ratio

of 1.7 in the HWSE-M to a ratio of 2.8 in the HWSE-P. As described in the SAP, it was anticipated that a fraction containing reduced levels of both HMWAHs and low-molecular weight AHs (LMWAHs) could be prepared; however, it was not practical to eliminate or significantly reduce the proportion of both HMWAHs and LMWAHs without losing the CHs as well. Nevertheless, using pentane rather than methylene chloride in the extraction process reduced the proportion of HMWAHs nearly 47% while maintaining the chlorinated butadienes at nearly 88% of original levels (Tables 2 and 3). Hence, this extraction approach provided an opportunity to evaluate whether there is an interaction between HMWAHs and CHs in affecting the tissue concentration of chemical contaminants and biomarker of exposure responses in juvenile chinook salmon.

Measurement of Contaminant Exposure

Analyses of chemical concentrations or biochemical parameters were not conducted on all treatment groups. Tissue levels of PAHs were not measured, because of the rapid metabolism of PAHs in the liver of fish (Varanasi et al. 1989). Similarly, DNA adduct levels were not measured in the HCBD and PCB-exposed fish, because PCBs have not been shown to form adducts with DNA (Nath et al. 1991), and HCBD is not expected to form DNA adducts. In addition, analyses for CH exposure (i.e., ΣPCBs) were not performed on fish exposed to PAHs only.

Chemical Analysis Results:

As mentioned above, tissue concentrations of chemical contaminants were measured in samples collected at 6 d and 20 d from the time-response study, and at 60 d from the growth study.

PCB Liver Levels : Liver PCB concentrations were significantly elevated at 6 d post exposure in juvenile chinook salmon receiving PCBs or either of the Hylebos Waterway sediment extracts (Fig. 1). At this time-point, the concentration of Σ PCBs in livers of the group receiving PCBs alone was 23,000 ppb compared to the basal levels of approximately 70 ppb Σ PCBs in the solvent-vehicle treated group. Although PCBs in the administered dosages of both extracts were low, ca. 0.03 mg Σ PCBs/kg fish, the level of PCBs in liver showed an increase of 2 times the PCB level of solvent-vehicle and reference sediment extract (NQSE) groups. There were no significant differences in the total PCB tissue levels observed between the HWSE-P and HWSE-M groups confirming that the actual dose of PCBs administered in either extract was similar. Liver PCB levels decreased by day 60 to about 10% of the observed maximum levels at 6 d in the HWSE-P and HWSE-M exposed groups, whereas the liver PCB level in the PCB treated group declined to 5% of maximum level at 6 d post exposure. Liver PCB levels in the

NQSE and solvent vehicle treated groups were near background levels, 70 ppb at day 6 and 20 ppb by the end of the experiment.

PCB Whole Body Levels: Total PCB levels in whole body followed the same trend as in the hepatic tissues, with the highest levels observed at 6 d post exposure for the PCB (14,500 ppb), HWSE-M and HWSE-P (both at ~ 50 ppb) treated groups as compared to control levels of A/E and NQSE treated groups (both at 28 ppb). Whole body PCB levels in HWSE-M and HWSE-P exposed fish declined to 70% to 80% of their respective maximum levels by 60 d (Fig. 2). Total PCB levels at 60 d in whole body tissues of PCB injected fish were still at 30% of maximum levels suggesting a shift of PCBs from the liver to body tissues.

HCBD Liver Levels: The highest HCBD level (2,900 ppb) was observed at 6 d post injection in the HCBD treated group, about 4 orders of magnitude higher than the control groups (Fig. 3). These levels, however, quickly declined at day 20 to 55 ppb, and returned to basal levels by 60 d. At 6 d post exposure, the sediment extract treated groups (HWSE-M and HWSE-P) exhibited significantly elevated HCBD levels, about 6 and 3 times as high as the A/E group, respectively. The levels observed at 6 d in the HWSE-M and HWSE-P treated groups were also 8 times and 4 times as high as the NQSE treated group, respectively. By day 20 the levels of HCBD in the livers of the sediment extract treated groups were at basal levels.

HCBD Whole Body Levels: At 6 d post exposure, HCBD levels in whole body tissue of both HWSE-M and HWSE-P treated groups were 110 times and 20 times as high as the A/E treated group, respectively, and 150 times and 30 times as high as the NQSE treated group (Fig. 4). While the concentration of HCBD in whole body tissues of the HWSE-M group was approximately 3 times as high as HCBD concentration in the hepatic tissues at 6 d, this was not observed in the HWSE-P treated group where HCBD levels were similar in both tissue types. Moreover, the mean concentration of HCBD in whole body tissue of HCBD only group was approximately 20% of the concentration in hepatic tissuemeasured at 6 d post exposure. The current findings also showed that HCBD in both tissues rapidly declined with time.

Biochemical Analyses

Although samples collected at all time points were analyzed for biliary FAC levels, hepatic CYP1A activity and DNA adducts, as mentioned above, results reported for the 6 and 20 d time-points are from samples collected in the time-response experiment; and 60 d data are from samples collected in the growth experiment that was conducted concurrently (Casillas et al. 1998).

Biliary FACs: Biliary FAC concentration was normalized to protein content in the bile sample. The variability in the bile metabolite levels associated with feeding status of sampled fish is reduced using this normalization procedure; the level of protein in bile reflects the water content of bile (Collier and Varanasi 1991). The concentrations of biliary FACs,

measured at benzo(a)pyrene wavelengths (380 nm. ex. and 430 nm. em.) in fish treated with the PAH model mixture revealed a maximum FAC level at 6 d post exposure (though this difference was not significant at the $p<0.05$ level). By 20 d there was no evidence of increased levels of biliary FACs in fish from the PAH treatment group (Fig. 5). Exposure to a single injection of either sediment extract at the dosages used in this laboratory experiment did not appear to result in any significant increases in biliary FAC levels.

Hepatic CYP1A Activity: Cytochrome P4501A (CYP1A) enzyme activity was responsive at the low administered dosages of contaminants in the Hylebos sediment extracts. Aryl hydrocarbon hydroxylase (AHH) activity ranged from 150 (A/E) to a high of 1100 (HWSE-M) pmol BaP equivalents/mg protein/min at 6 d post exposure (Fig. 6). The PAH, PCB, HWSE-M, HWSE-P, and NQSE treatment groups all exhibited elevated AHH activity. The HWSE-M treated group showed the highest activity (~ 7 times) at 6 d post exposure as compared to the A/E treated group. CYP1A activity in fish treated with HWSE-M was about 3 times as high as the NQSE treated group. The HCBD treated group did not show any induction of AHH activity. At 60 d post exposure, CYP1A activity in all treatment groups returned to basal levels except for the PCB treated group, which remained elevated (~ 4 times as high as the A/E and NQSE groups).

DNA Adducts: The levels of DNA adducts, at 6 d post exposure, in the HWSE-P, HWSE-M and PAH treated groups were significantly greater than those in the NQSE treated group (Fig.7). The increased DNA adduct levels in the PAH, HWSE-M and HWSE-P treated groups persisted through 20 d, but declined to approximately 20% of the level measured at 6 d by the end of the experiment. Hepatic DNA adduct profiles from the acetone/Emulphor (solvent vehicle) injected fish were uncharacteristic of those generated previously in fish injected with this solvent vehicle; therefore they were not used as the control group in the interpretation of the DNA adduct data. The reference sediment extract (NQSE) treated group was used as the control. Additional information on previous DNA adduct data for A/E treated fish is presented in Appendix 2. The DNA adduct profiles and levels in the NQSE treated fish were representative of those typically observed in fish collected from uncontaminated sites, injected with uncontaminated sediment extracts or the solvent vehicle, acetone/Emulphor (French et al. 1996, Stein et al. 1993). In addition, the chemical levels and other biochemical responses measured in the NQSE-treated fish were comparable to those from the A/E treated fish (Figs. 1-6).

DISCUSSION OF MAJOR FINDINGS

PCBs and PAHs are primarily responsible for the alterations in biomarker responses in juvenile chinook salmon.

Laboratory exposure of juvenile chinook salmon to individual classes of compounds characteristic of the Hylebos Waterway demonstrated that PAHs clearly induced CYP1A activity and increased levels of DNA adducts in livers of juvenile chinook salmon. Evidence for increases in biliary levels of FACs was also observed in juvenile chinook salmon at 6 d following exposure to PAHs. Levels of PAHs in the body and liver were not measured, because unlike PCBs, PAHs are rapidly metabolized by the liver and their metabolites can be detected in the bile of exposed animals (Varanasi et al. 1989). Our findings are largely consistent with previous laboratory studies showing that biliary FACs, CYP1A activity and DNA adducts are sensitive and responsive to PAH exposure (Stein et al. 1992, Collier and Varanasi 1991). Although the increase in biliary FAC levels due to exposure to PAHs at 6 d post exposure was higher than that for any of the other treatment groups, it was not statistically significant. This low response of FACs to PAH exposure was not expected. Species-specific differences may be a factor, as previous extensive studies of the time- and dose-responsiveness of biliary FACs in flatfish have shown the sensitivity of this measure to PAH exposure. However, without additional information on the time-course response of FACs in juvenile chinook salmon exposed to PAHs, any further explanation of the findings would be speculative.

Juvenile chinook salmon exposed to PCBs had elevated body and liver levels of PCBs as well as induction of hepatic CYP1A activity. This is consistent with other studies showing similar CYP1A induction by PCB mixtures (Safe 1994; Collier and Varanasi, 1991). Evidence of HCBD exposure was detected as increased concentrations of HCBD in liver and whole body of juvenile salmon. Unlike PCBs or PAHs, no evidence of hepatic CYP1A induction or altered biliary FACs was observed, upon exposure to HCBD, at any time during the 60 d monitoring period. It was not surprising that the biochemical measurements made in this study did not show any response following HCBD exposure because HCBD was not expected to induce a response in the biomarkers measured. The types of chemicals that induce a response in the three biomarkers measured have very different chemical structures than HCBD. Moreover, we are not aware of any other validated biochemical responses which could be expected to change following acute exposure to HCBD in fish. It is possible that there may have been kidney damage resulting from the HCBD exposure, as this compound is known to be nephrotoxic in mammals (Nakagawa et al. 1998). Histopathological examination of fixed kidney tissue from HCBD-exposed salmon could address this question.

The biochemical responses to the sediment extract exposures were consistent with the observations made with individual or model mixtures of chemical compounds. For example, significant increases in tissue levels of PCBs and hepatic CYP1A activity were observed in juvenile chinook salmon exposed to single injection of either Hylebos sediment extract. Because CYP1A activity was significantly elevated at 20 d post exposure in fish treated with PCBs, but not with PAHs, the elevated CYP1A response at the later time points in the extract treated fish is likely due to PCBs or other compounds similar in structure and persistence in fish tissues as PCBs that are present in the Hylebos Waterway sediment extracts. Similarly, because fish exposed to either of the two extracts exhibited elevated DNA adduct levels at 20 d post exposure in the same manner as those exposed to PAHs only, this elevated response was likely a consequence of PAH exposure. Biliary FACs were not elevated at the earliest time period monitored (6 d post exposure) following exposure to either HWSE. While this lack of a FAC response was not expected, as discussed above it is not appropriate to speculate as to the reason for this lack of response. The overall responses from exposure to either of the HWSEs (HWSE-M and HWSE-P) were similar, which is consistent with the similarity in the dosage and composition of chemical contaminants in these two extracts. Furthermore, the similarity in the response to the two extracts and lack of response to the reference sediment extract (NQSE) supports the conclusion that it is the chemical contaminants present in the Hylebos Waterway sediments, and not naturally occurring compounds, that were responsible for the increases in DNA adducts and CYP1A activity. The apparently higher HCBD concentration in whole body tissue observed at 6 d in the HWSE-M group compared to the HWSE-P group may be due to the fact that the levels being quantitated are approaching the detection limit, making accurate quantitation more difficult.

Overall, the current findings show that each class of toxic chemicals characteristic of the Hylebos Waterway produced a signature response from the suite of biochemical and chemical endpoints employed in this study. When we evaluated the responses of juvenile chinook salmon exposed to the complex mixture of contaminants in the two Hylebos Waterway sediment extracts, the collective biomarker and chemical endpoint response generally reflected the contribution of the individual component classes of this complex contaminant mixture. Thus, the integrated use of a suite of measurements allowed for identification of the compound classes likely responsible for specific responses. This information increases our ability to interpret chemical exposure history of juvenile salmon from the Hylebos Waterway.

Compounds such as HCBD, PCBs, and PAHs, characteristic of the Hylebos Waterway, persist for an extended period after exposure.

Measures of chemical concentrations in tissues of exposed animals explicitly reveal the persistence and magnitude of exposure to chemical contaminants that are not easily degraded by biological processes, and provide information for linking biological effects to chemical contaminants. In the current study, when juvenile chinook salmon were exposed to PCBs at a dose equivalent to 20% of the 96 hr LD_{50}, this exposure was evident in liver and whole body PCB levels at the end of the 60 d experimental period. At this time point, whole body PCB concentrations had declined to approximately 30% of maximum levels measured, and liver PCB concentration declined to 5% of the levels observed at 6 d post exposure. These findings demonstrate that appreciable levels of PCBs persist in the tissues for a significant period of time, weeks after the exposure from external sources is terminated. On the basis of these findings, it is evident that the potential for biological effects from PCB exposure may also persist for an extended period. This conclusion is supported by the observation of induced CYP1A activities at 60 d in the PCB treated fish.

Persistence of PCBs in tissues was also observed in fish receiving either of the Hylebos Waterway sediment extracts. Elevated liver PCB concentrations were observed in fish exposed to either HWSE-M or HWSE-P sampled at 6 d post exposure, and body concentrations of PCBs were significantly elevated for at least 20 d post exposure. The lower magnitude and the apparent shorter duration of the response (based on the tissue concentrations) in fish exposed to sediment extracts are expected with a single injection of much lower dose of PCBs present in either of the Hylebos Waterway sediment extracts (28 to 32 μg PCBs/kg fish) compared to fish exposed to PCBs only (28,000 μg PCBs/kg fish). The concentrations of PCBs measured in liver tissues of the extract exposed fish were comparable to levels observed in juvenile chinook and chum salmon collected in the field study (Round I). Thus, it is likely that juvenile salmon may experience the biological consequences of a short-term exposure to PCBs for at least 3 weeks after leaving the Hylebos Waterway.

Elevated HCBD levels persisted in whole body and liver tissue of juvenile salmon exposed to HCBD only, but not to the same extent as PCBs. Whole body HCBD concentrations were significantly elevated through 20 d, and by 60 d HCBD levels were still elevated but no longer statistically different (at the $p<0.05$ level) from controls. The decline in HCBD levels was even more rapid in liver tissue. Hepatic HCBD concentrations were significantly elevated at 6 and 20 d post exposure, but were approaching the limits of detection by 60 d post exposure in HCBD injected fish. Fish injected with either of the two extracts also exhibited evidence of HCBD exposure at 6 d post injection; however, in contrast to the HCBD only treated group, HCBD was not detectable by 20 d post exposure. These findings showing that HCBD levels

declined more rapidly than PCB levels suggest that either metabolism, excretion or both metabolism and excretion of HCBD was greater in juvenile chinook salmon.

The persistence of the hepatic CYP1A activity and increased DNA adduct levels observed in fish exposed to sediment extracts from the Hylebos Waterway can be largely attributed to specific classes of compounds based on the responses observed from exposure to PCBs or PAHs individually. For example, CYP1A activity remained elevated for up to 20 d post exposure in juvenile salmon exposed to sediment extracts from the Hylebos Waterway, in the same manner as in fish exposed to PCBs only, thus indicating that the persistence of CYP1A response in this study is likely due to exposure to PCBs. Other substances, such as dioxins and dibenzofurans, could also potentially be contributing to such induction. However, these types of compounds were not analyzed in the current set of studies. Similarly, hepatic PAH-DNA adduct levels in sediment extract treated fish also remained significantly elevated at 20 d post exposure at about 3 times as high as the levels observed in the NQSE group. This finding suggests that exposure to PAHs results in persistent levels of PAH-DNA adducts for 1 - 3 weeks after a short-term exposure in juvenile salmon. This finding is consistent with studies with English sole showing that DNA adducts in liver persist for > 3 weeks (Stein et al. 1993).

Overall, these findings support the conclusion that chemical tissue burdens of chlorinated contaminants as well as biochemical responses will likely persist after juvenile chinook salmon leave the estuary and exposure to toxic chemicals from sources in the Hylebos Waterway ceases. Furthermore, the collective findings for CYP1A and DNA-adducts suggest the potential for effects from exposure to PCBs and PAHs, and that juvenile salmon may experience the biological consequences of a short-term exposure to these toxic compounds which can persist for at least 1 - 3 weeks after leaving the Hylebos Waterway.

Responses of juvenile chinook salmon exposed to sediments extracts from the Hylebos Waterway in the laboratory were comparable to those observed in juvenile chinook and chum salmon from the Hylebos Waterway.

When we evaluated the biomarker responses due to exposure to a mixture of PAHs, PCBs, and HCBD in the laboratory, as represented by sediment extracts of Hylebos Waterway sediments, the collective response was comparable to the responses observed in juvenile salmon sampled directly from the Hylebos Waterway. The current findings showed that total PCBs and HCBD concentrations in liver of sediment-extract injected fish observed at 6 d post injection were similar to those measured in salmon captured in the Hylebos Waterway during Round I of the Fish Injury Study (Collier et al. 1998). Thus, biomarker responses of juvenile salmon injected with a single dose of the sediment extracts in the laboratory reflected the exposure of naturally outmigrating juvenile salmon to chemical contaminants present in the Hylebos

Waterway. More importantly, the current laboratory results suggest that a relationship exists between alterations in the CYP1A and DNA adduct responses and exposure of juvenile chinook salmon to chemical contaminants present in this Waterway. Furthermore, the findings from this study indicated that exposure to chemical contaminants from the Hylebos Waterway elicit chemical and biochemical changes which can persist for up to 3 weeks after exposure ceases. The findings from the disease challenge (Part 1) and growth (Part 2) experiment components of Round II of the Hylebos Fish Injury Study also indicated that juvenile salmon exposed to the same test solutions used in this study exhibited impaired growth and increased disease susceptibility (Arkoosh et al. 1998a, Casillas et al. 1998). In previous studies, fish naturally exposed to a similar suite of contaminants from the Duwamish Waterway also exhibited immune dysfunction (Arkoosh et al. 1991, 1994) as well as increased disease susceptibility (Arkoosh et al. 1998b) and impaired growth (Casillas et al. 1995b). Hence, we conclude that juvenile salmon from the Hylebos Waterway have an increased risk of deleterious biological effects (altered immune function, increased disease susceptibility, and reduced growth) due to exposure to the chemical contaminants present in this Waterway.

HYLEBOS FISH INJURY STUDY
Round II

Part 3: Exposure of juvenile chinook salmon to chemical contaminants specific to the Hylebos Waterway: Tissue concentrations and biochemical responses.

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LIST OF ABBREVIATIONS

AHs	aromatic hydrocarbons
AHH	aryl hydrocarbon hydroxylase
ANOVA	analysis of variance
CHs	chlorinated hydrocarbons
CYP1A	cytochrome P4501A
DNA	deoxyribonucleic acid
GC/MS	gas chromatography/mass spectrometry
HCBD	hexachlorobutadiene
HWSE-M	Hylebos Waterway sediment extract prepared with methylene chloride
HWSE-P	Hylebos Waterway sediment extract prepared with pentane
LD	Lethal dose
NOAA	National Oceanic and Atmospheric Administration
NMFS	National Marine Fisheries Service
NWFSC	Northwest Fisheries Science Center
NQSE	Nisqually River sediment extract
PCBs	polychlorinated biphenyls (ΣPCBs - sum of PCB congeners, total PCBs)
PAHs	polycyclic aromatic hydrocarbons
SAP	Sampling and Analysis Plan

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EXECUTIVE SUMMARY

The Hylebos Waterway of Commencement Bay, an urban estuary in central Puget Sound, Washington, is severely contaminated with a variety of organic and inorganic chemicals. Juvenile salmon inhabit this waterway in the late spring and early summer during their migration from fresh water to the open ocean. Studies conducted in 1989 and 1990 revealed that juvenile chinook salmon migrating through Commencement Bay had elevated concentrations of polycyclic aromatic hydrocarbons (PAHs) and chlorinated hydrocarbons (CHs) or their derivatives in tissues, bile and stomach contents, and that they exhibited biochemical changes indicative of contaminant exposure. Round I of the Hylebos Fish Injury Study, conducted in 1994 and 1995, showed that both juvenile chum and chinook salmon sampled from the Hylebos Waterway were also exposed to a wide range of chemical contaminants (Collier et al. 1998). Furthermore, the levels of exposure and biochemical responses were comparable to levels that have previously been associated with impaired growth, immunosuppression, and increased mortality following pathogen exposure in juvenile salmon; biological effects that can have significant population impacts. Whether juvenile salmon exposed in the laboratory to anthropogenic chemical contaminants specific to the Hylebos Waterway would exhibit similar chemical and biochemical changes was unknown.

In 1996, Round II of the Hylebos Fish Injury Study continued with laboratory experiments designed to establish links between chemical exposure and injury as well as quantify the extent of the injury. Results of the first two laboratory experiments (disease challenge and growth) in Round II (see SAP, Appendix 1) show that juvenile salmon exposed to PCBs, PAHs, HCBD, and organic-solvent extracts of sediments from the Hylebos Waterway exhibit increased disease susceptibility (altered immunocompetence) (Part 1 of Round II Hylebos Fish Injury Study) and reduced growth (Part 2 of Round II Hylebos Fish Injury Study). Within the scope of Round II studies, we needed to further identify the chemical contaminants potentially responsible for causing injury and examine the persistence of chemical contaminants and biochemical responses which were measured in Round I.

The objectives of the present laboratory study (Part 3 of Round II Hylebos Fish Injury Study) were to determine: 1) classes of chemical compounds that produce alterations in chemical and biochemical measures of contaminant exposure in juvenile salmon tissues, 2) the persistence of chemicals in the tissues of exposed fish, and 3) the magnitude and persistence of biochemical responses as a result of exposure to chemical compounds characteristic of the Hylebos Waterway. To accomplish these objectives, juvenile salmon were injected intraperitoneally (i.p.) with a single dose of either 1) hexachlorobutadiene (HCBD), a signature compound of the Hylebos Waterway, 2) an extract made from Hylebos Waterway sediment using methylene

chloride as the extracting solvent (HWSE-M), 3) an extract made from Hylebos Waterway sediment using pentane as the extracting solvent (HWSE-P), 4) a model mixture composed of 10 high-molecular weight polycyclic aromatic hydrocarbons (PAHs) proportional to their concentrations in a sediment sample from the Hylebos Waterway, 5) the PCB mixture, Aroclor 1254, 6) a reference sediment extract made from Nisqually River estuary sediment (NQSE) using methylene chloride as the extracting solvent, or 7) acetone/Emulphor (A/E), the solvent vehicle. Bile, liver, and gutted-whole body were collected at different intervals up to 60 d post exposure and analyzed for chemical exposure including tissue concentrations of CHs (e.g., HCBD, chlorinated pesticides and PCBs); as well as biochemical responses including biliary levels of fluorescent aromatic compounds (FACs), hepatic cytochrome P4501A-dependent monooxygenase activity (CYP1A) and hepatic DNA adduct levels.

Results from this portion of the study (Part 3) conducted in Round II of the Hylebos Fish Injury Study showed that: 1) PCBs and PAHs induced alterations in chemical and biochemical measures of exposure in juvenile salmon after single-dose injection, 2) PCBs, cytochrome P4501A induction and PAH-DNA adducts persisted for up to 60 days in the tissues of exposed animals after single-injection exposure, 3) HCBD exposure resulted in increased tissue concentrations, but did not induce, as expected, any biochemical response at the tissue levels of exposure used in this laboratory study, and 4) the tissue levels of PCBs, HCBD, and the biochemical responses in juvenile salmon treated with the Hylebos sediment extracts were comparable to the levels and responses observed in salmon sampled directly from the Hylebos Waterway in Round I (Collier et al. 1998). These findings, in conjunction with the findings from the first two laboratory experiments of Round II [showing impaired disease resistance (Part 1) as well as impaired growth (Part 2) in juvenile salmon exposed to the same Hylebos sediment extracts], support the conclusion that juvenile salmon residing in the Hylebos Waterway will likely exhibit impaired growth and increased disease susceptibility as a result of their dependence on this contaminated habitat.

INTRODUCTION

Estuaries are important habitats for several Pacific salmonid species (*Oncorhynchus* spp.), including the fall-spawning chinook which use estuaries as juvenile rearing habitat (Thorpe 1994). The estuary acts as an intermediate environment for their physiological adaptation to ocean conditions, a profitable foraging ground and a refuge from predators. Results from recent studies of juvenile chinook salmon (*Oncorhynchus tshawytscha*) captured from the Duwamish Waterway, a highly contaminated urban estuary in Puget Sound, consistently showed elevated exposure to polycyclic aromatic hydrocarbons (PAHs) and chlorinated hydrocarbons (CHs) when compared to juvenile chinook salmon captured from the Nisqually River Estuary, a minimally contaminated non-urban area (McCain et al. 1990, Collier et al. 1998). Moreover, increased exposure to these chemical contaminants led to induction of cytochrome P4501A (CYP1A) enzyme activities and damage to hepatic DNA in juvenile chinook salmon as they migrated through the contaminated estuarine environments of the Duwamish Waterway as well as Commencement Bay in Puget Sound, Washington (Stein et al. 1995).

In Round I of the Hylebos Waterway Fish Injury Assessment, juvenile chum (*Oncorhynchus keta*) and chinook salmon from the Hylebos Waterway showed elevated PAH metabolites in bile and CHs in liver which were comparable to those found in juvenile chinook salmon from the Duwamish Waterway (Collier et al. 1998). Furthermore, the levels of exposure were similar to those associated with impaired growth, immunosuppression, and increased mortality following pathogen exposure in chinook salmon collected from the Duwamish Waterway (Arkoosh et al. 1991, Casillas et al. 1995a). In addition, juvenile chum and chinook from the Hylebos Waterway had concentrations of hexachlorobutadiene (HCBD) in the liver that exceeded those found in any of our previous field studies with salmon (Varanasi et al. 1993). Associated with these increased concentrations of chemicals were indications of early biological alterations and damage, as shown by increases in hepatic CYP1A-associated enzyme activity and increased levels of DNA adducts (Collier et al. 1998). Increases in both of these measures are well established as being linked to contaminant exposure (Collier and Varanasi 1991, Varanasi et al. 1992, Stein et al. 1992). DNA adducts represent reversible damage to genetic material that has been shown to be associated with hepatic lesions in fish (Myers et al. 1998). In the present study DNA adducts were used as an indicator of exposure to genotoxic polycyclic aromatic compounds based on our previous studies (French et al. 1996, Stein et al. 1992, 1994). However, from the findings in Round I, it was not clear which classes of contaminants found in the Hylebos Waterway contributed to these biological alterations; nor was it clear how long elevated body levels of contaminants or biochemical alterations would persist after fish moved out of the contaminated estuary and into marine waters.

The objective of the present laboratory study was to assess the time-responsiveness of tissue CHs, biliary FACs, hepatic CYP1A, and hepatic DNA adducts (measured in Round I) in juvenile chinook salmon exposed to contaminants specific to the Hylebos Waterway and sampled for up to 60 days following a single exposure. Specifically in July 1997, juvenile chinook salmon from a local hatchery were injected intraperitoneally (i.p.) with: 1) hexachlorobutadiene (HCBD), a signature compound of the Hylebos Waterway, 2) an extract made from Hylebos Waterway sediment using methylene chloride as the extracting solvent (HWSE-M), 3) an extract made from Hylebos Waterway sediment using pentane as the extracting solvent (HWSE-P), 4) a model mixture composed of 10 high-molecular weight polycyclic aromatic hydrocarbons (PAHs) proportional to their concentrations in a sediment sample from the Hylebos Waterway, 5) the PCB mixture, Aroclor 1254, 6) a reference sediment extract made from Nisqually River estuary sediment (NQSE) using methylene chloride as the extracting solvent, or 7) acetone/Emulphor (A/E), the solvent vehicle. The results from this study will provide a basis for evaluation of the relationship between the level of exposure to chemical contaminants specific to the Hylebos Waterway and the significant biological effects observed in juvenile chinook salmon in the previous laboratory studies, and will also allow for comparison to the results obtained for juvenile chinook salmon sampled directly from the Hylebos Waterway in Round I.

METHODS

Details of the experimental design and methods used in the present study are described in the addendum to the SAP (Appendix 1). The chemical compositions of the NQSE, HWSE-M, HWSE-P sediment extracts and their concentrations are listed in Table 1, 2, and 3, respectively. The composition of the PAH model mixture is listed in Table 4.

Exposure Dosage Assessment

All fish were injected intraperitoneally (i.p.) with PAH model mixture, HCBD, PCB mixture (Aroclor 1254), sediment extracts from the Hylebos Waterway or the Nisqually River estuary mixed with the solvent vehicle, acetone:Emulphor (1:1, v/v), or the solvent vehicle alone. The objective of administering HWSE-M, HWSE-P, a model mixture of PAHs, Aroclor 1254, and HCBD was to expose juvenile salmon to known quantities of compounds representative of chemical contaminants present in the sediment from the Hylebos Waterway.

The Nisqually River estuary sediment extract (NQSE) was prepared from sediment collected near the mouth of the Nisqually River. The chemical profile in this extract is representative of sediment from a non-urban site that is minimally contaminated (Table 1). The NQSE sediment extract was prepared using methylene chloride as the extracting solvent. The injection dosage for this extract was 200 g sediment extracted/ kg fish which is equivalent to administering 0.005 mg ΣAHs/kg fish, 0.0004 mg ΣPCB/kg fish, and < 0.001 µg HCBD/kg fish. Juvenile chinook salmon treated with NQSE served as a control group for the Hylebos sediment extract treated fish, providing a more appropriate control group to assess the influence of Hylebos-associated contaminated sediment extracts on the chemical and biochemical parameters measured in juvenile chinook salmon.

The Hylebos Waterway sediment extracts (HWSE-M and HWSE-P) were prepared from sediment collected near the mouth of the Hylebos Waterway from Stations HY-07, -08, and -09, as designated during the sediment injury studies conducted during Round I of the Hylebos Damage Assessment investigations. (see Appendix D in Collier et al., 1998). These sediment extracts were prepared using two different solvents to obtain test solutions that included specific chemical compounds present in sediment from the Hylebos Waterway. The composition of analytes in the two Hylebos Waterway extracts is listed in Tables 2 and 3. The HWSE-M sediment extract was prepared using methylene chloride as the extracting solvent. The chemicals present in the HWSE-M represent the full range of chemicals (AHs and CHs) that may be available to fish. The HWSE-P extract was prepared using pentane to reduce the proportion of high-molecular weight AHs (HMWAHs) extracted, thereby increasing the concentration of CHs relative to HMWAHs. Some CHs present in the HWSE-P were partly removed in this

preparation, but to a lesser degree than the PAHs. The HWSE-M was administered at a dose of 200 g sediment extracted/kg fish which is equivalent to 0.35 mg ΣPAHs/kg fish, 0.032 mg ΣPCBs/kg fish, and 0.038 mg HCBD/kg fish; whereas, the HWSE-P extract was administered at a dosage of 400 g sediment extracted/kg fish which is equivalent to 0.24 mg ΣPAHs/kg fish, 0.028 mg ΣPCBs/kg fish, and 0.045 mg HCBD/kg fish. A dose equivalent to 400 g of HWSE-P sediment extracted/kg fish was used so that the levels of measured chemical contaminant administered for the two Hylebos sediment extracts would be comparable.

A model mixture of polycyclic aromatic hydrocarbons (PAHs) containing 10 high-molecular weight PAHs was prepared to reflect the same ratios of these analytes as previously found in sediment sampled during Round I of the Hylebos Damage Assessment studies at Station HY-24 (Appendix D, Collier et al. 1998). The PAH model mixture in acetone/Emulphor was administered at a dosage of 6.3 mg ΣPAHs/kg fish. The effect of PCBs was evaluated using a commercial mixture (Aroclor 1254). The PCB mixture prepared in acetone/Emulphor was administered at a dosage of 28 mg ΣPCBs/kg fish. The HCBD solution prepared in acetone/Emulphor was administered at a dosage of 21 mg HCBD/kg fish. All test solutions, including controls, were each administered at a volume equivalent to 1.5 µl solution/g fish.

Experimental conditions , mortality and sampling strategies

Ambient water temperatures during the course of the study ranged from 11.6°C at 0 d to 12.8 °C at 60 d post exposure (Casillas et al. 1998). The mean (± SD) water temperature was 12.2± 0.4 °C. Temperature was kept relatively constant by drawing seawater from a depth of approximately 50 feet, thereby minimizing the influence of more rapid changes in surface-seawater temperatures.

Fish were fed to satiation twice a day, once in the morning and once in the afternoon with food pellets (Biodry 1000, Bioproducts).

Recorded mortalities of experimental fish ranged from 6% to 19% (18 to 53 animals) for each of the treatment groups (300 fish per group) during the experimental period (Table 5). The highest number of mortalities was observed in juveniles receiving either the HWSE-M or the PCB formulation (Aroclor 1254). In contrast, the lowest mortalities were observed in juveniles receiving the solvent vehicle (acetone/Emulphor). With the exception of HWSE-P, HCBD, and PCB treated groups, mortalities were low and stable in the second half of the experimental period (Table 5). During the course of the experiment, we could not account for approximately 12% of the injected fish and we assume that these fish either escaped from the tanks through the exiting water standpipe, or gaps in the tank covers (Appendix 3). Exposed fish from all 7 treatments were sampled at 6 d and 20 d post exposure; but shortly after that it became apparent that insufficient numbers of fish would be available for the 60 d sampling time-point. Hence, the

HWSE-M and NQSE treated groups were sampled at 33 d post exposure, the solvent vehicle group was sampled at 35 d post exposure, and the HCBD and HWSE-P groups were sampled at 56 d post exposure. The PAH and PCB groups were sampled at 62 d post exposure. All three biochemical parameters were analyzed from all samples collected, except for chemical concentrations in tissues where only samples collected at 6 d, 20 d from the time-response study and samples collected at 60 d from the growth study were analyzed. To compensate for the treatment groups that could not be carried out to the full 60 d in this experiment, appropriate samples of fish which received the same exposure were collected from the growth experiment, conducted simultaneously with the biomarker experiment (Casillas et al, 1998). Therefore, the results presented in this report were of samples from all seven treatments collected at 6 d and 20 d post exposure from the biomarker study, and 60 d post exposure from the growth study.

Prior to analysis, samples were composited to obtain sufficient tissue and fluid for the biochemical and chemical analyses. Liver and bile from 20 individual fish were composited for biochemical analyses such as PAH metabolites in bile, hepatic CYP1A activity, and levels of hepatic DNA adducts. For chemical analyses of CHs in whole body tissues, five individual gutted whole bodies were composited. At each time point, three composites of bile, livers, and whole gutted bodies were collected per treatment. Composited liver samples were flash-frozen in liquid nitrogen and subsequently stored at -80°C until analysis. Composited bile and whole body samples were kept on ice and subsequently stored at -20°C until analysis.

Statistical methods

Statistical significance of the biomarker responses at 6, 20, and 60 d post exposure was assessed using ANOVA (Super ANOVA, Abacus Concepts Inc., Berkeley, CA, 1989). Significance of results of treatment groups compared to the control groups of fish (fish receiving acetone/Emulphor or the reference Nisqually River estuary sediment extract) was evaluated using Dunnett's Multiple Comparison Test (Zar 1978) at $\alpha = 0.05$ for each variable independently.

RESULTS

Sediment Extract Chemistry

In this study, two different extraction methods were used to isolate non-polar toxic CHs and AHs (polar compounds were removed from the extracts) from a representative Hylebos Waterway sediment. The major difference in these methods was the solvent used in the extraction process (pentane or methylene chloride). In the pentane extract of the Hylebos Waterway sediment (HWSE-P), the proportion of high-molecular weight AHs (HMWAHs) was reduced relative to the CHs; therefore, the ratio of CHs to HMWAHs was increased from a ratio

of 1.7 in the HWSE-M to a ratio of 2.8 in the HWSE-P. As described in the SAP, it was anticipated that a fraction containing reduced levels of both HMWAHs and low-molecular weight AHs (LMWAHs) could be prepared; however, it was not practical to eliminate or significantly reduce the proportion of both HMWAHs and LMWAHs without losing the CHs as well. Nevertheless, using pentane rather than methylene chloride in the extraction process reduced the proportion of HMWAHs nearly 47% while maintaining the chlorinated butadienes at nearly 88% of original levels (Tables 2 and 3). Hence, this extraction approach provided an opportunity to evaluate whether there is an interaction between HMWAHs and CHs in affecting the tissue concentration of chemical contaminants and biomarker of exposure responses in juvenile chinook salmon.

Measurement of Contaminant Exposure

Analyses of chemical concentrations or biochemical parameters were not conducted on all treatment groups. Tissue levels of PAHs were not measured, because of the rapid metabolism of PAHs in the liver of fish (Varanasi et al. 1989). Similarly, DNA adduct levels were not measured in the HCBD and PCB-exposed fish, because PCBs have not been shown to form adducts with DNA (Nath et al. 1991), and HCBD is not expected to form DNA adducts. In addition, analyses for CH exposure (i.e., ΣPCBs) were not performed on fish exposed to PAHs only.

Chemical Analysis Results:

As mentioned above, tissue concentrations of chemical contaminants were measured in samples collected at 6 d and 20 d from the time-response study, and at 60 d from the growth study.

PCB Liver Levels : Liver PCB concentrations were significantly elevated at 6 d post exposure in juvenile chinook salmon receiving PCBs or either of the Hylebos Waterway sediment extracts (Fig. 1). At this time-point, the concentration of Σ PCBs in livers of the group receiving PCBs alone was 23,000 ppb compared to the basal levels of approximately 70 ppb Σ PCBs in the solvent-vehicle treated group. Although PCBs in the administered dosages of both extracts were low, ca. 0.03 mg Σ PCBs/kg fish, the level of PCBs in liver showed an increase of 2 times the PCB level of solvent-vehicle and reference sediment extract (NQSE) groups. There were no significant differences in the total PCB tissue levels observed between the HWSE-P and HWSE-M groups confirming that the actual dose of PCBs administered in either extract was similar. Liver PCB levels decreased by day 60 to about 10% of the observed maximum levels at 6 d in the HWSE-P and HWSE-M exposed groups, whereas the liver PCB level in the PCB treated group declined to 5% of maximum level at 6 d post exposure. Liver PCB levels in the

NQSE and solvent vehicle treated groups were near background levels, 70 ppb at day 6 and 20 ppb by the end of the experiment.

PCB Whole Body Levels: Total PCB levels in whole body followed the same trend as in the hepatic tissues, with the highest levels observed at 6 d post exposure for the PCB (14,500 ppb), HWSE-M and HWSE-P (both at ~ 50 ppb) treated groups as compared to control levels of A/E and NQSE treated groups (both at 28 ppb). Whole body PCB levels in HWSE-M and HWSE-P exposed fish declined to 70% to 80% of their respective maximum levels by 60 d (Fig. 2). Total PCB levels at 60 d in whole body tissues of PCB injected fish were still at 30% of maximum levels suggesting a shift of PCBs from the liver to body tissues.

HCBD Liver Levels: The highest HCBD level (2,900 ppb) was observed at 6 d post injection in the HCBD treated group, about 4 orders of magnitude higher than the control groups (Fig. 3). These levels, however, quickly declined at day 20 to 55 ppb, and returned to basal levels by 60 d. At 6 d post exposure, the sediment extract treated groups (HWSE-M and HWSE-P) exhibited significantly elevated HCBD levels, about 6 and 3 times as high as the A/E group, respectively. The levels observed at 6 d in the HWSE-M and HWSE-P treated groups were also 8 times and 4 times as high as the NQSE treated group, respectively. By day 20 the levels of HCBD in the livers of the sediment extract treated groups were at basal levels.

HCBD Whole Body Levels: At 6 d post exposure, HCBD levels in whole body tissue of both HWSE-M and HWSE-P treated groups were 110 times and 20 times as high as the A/E treated group, respectively, and 150 times and 30 times as high as the NQSE treated group (Fig. 4). While the concentration of HCBD in whole body tissues of the HWSE-M group was approximately 3 times as high as HCBD concentration in the hepatic tissues at 6 d, this was not observed in the HWSE-P treated group where HCBD levels were similar in both tissue types. Moreover, the mean concentration of HCBD in whole body tissue of HCBD only group was approximately 20% of the concentration in hepatic tissuemeasured at 6 d post exposure. The current findings also showed that HCBD in both tissues rapidly declined with time.

Biochemical Analyses

Although samples collected at all time points were analyzed for biliary FAC levels, hepatic CYP1A activity and DNA adducts, as mentioned above, results reported for the 6 and 20 d time-points are from samples collected in the time-response experiment; and 60 d data are from samples collected in the growth experiment that was conducted concurrently (Casillas et al. 1998).

Biliary FACs: Biliary FAC concentration was normalized to protein content in the bile sample. The variability in the bile metabolite levels associated with feeding status of sampled fish is reduced using this normalization procedure; the level of protein in bile reflects the water content of bile (Collier and Varanasi 1991). The concentrations of biliary FACs,

measured at benzo(a)pyrene wavelengths (380 nm, ex. and 430 nm, em.) in fish treated with the PAH model mixture revealed a maximum FAC level at 6 d post exposure (though this difference was not significant at the $p<0.05$ level). By 20 d there was no evidence of increased levels of biliary FACs in fish from the PAH treatment group (Fig. 5). Exposure to a single injection of either sediment extract at the dosages used in this laboratory experiment did not appear to result in any significant increases in biliary FAC levels.

Hepatic CYP1A Activity: Cytochrome P4501A (CYP1A) enzyme activity was responsive at the low administered dosages of contaminants in the Hylebos sediment extracts. Aryl hydrocarbon hydroxylase (AHH) activity ranged from 150 (A/E) to a high of 1100 (HWSE-M) pmol BaP equivalents/mg protein/min at 6 d post exposure (Fig. 6). The PAH, PCB, HWSE-M, HWSE-P, and NQSE treatment groups all exhibited elevated AHH activity. The HWSE-M treated group showed the highest activity (~ 7 times) at 6 d post exposure as compared to the A/E treated group. CYP1A activity in fish treated with HWSE-M was about 3 times as high as the NQSE treated group. The HCBD treated group did not show any induction of AHH activity. At 60 d post exposure, CYP1A activity in all treatment groups returned to basal levels except for the PCB treated group, which remained elevated (~ 4 times as high as the A/E and NQSE groups).

DNA Adducts: The levels of DNA adducts, at 6 d post exposure, in the HWSE-P, HWSE-M and PAH treated groups were significantly greater than those in the NQSE treated group (Fig.7). The increased DNA adduct levels in the PAH, HWSE-M and HWSE-P treated groups persisted through 20 d, but declined to approximately 20% of the level measured at 6 d by the end of the experiment. Hepatic DNA adduct profiles from the acetone/Emulphor (solvent vehicle) injected fish were uncharacteristic of those generated previously in fish injected with this solvent vehicle; therefore they were not used as the control group in the interpretation of the DNA adduct data. The reference sediment extract (NQSE) treated group was used as the control. Additional information on previous DNA adduct data for A/E treated fish is presented in Appendix 2. The DNA adduct profiles and levels in the NQSE treated fish were representative of those typically observed in fish collected from uncontaminated sites, injected with uncontaminated sediment extracts or the solvent vehicle, acetone/Emulphor (French et al. 1996, Stein et al. 1993). In addition, the chemical levels and other biochemical responses measured in the NQSE-treated fish were comparable to those from the A/E treated fish (Figs. 1-6).

DISCUSSION OF MAJOR FINDINGS

PCBs and PAHs are primarily responsible for the alterations in biomarker responses in juvenile chinook salmon.

Laboratory exposure of juvenile chinook salmon to individual classes of compounds characteristic of the Hylebos Waterway demonstrated that PAHs clearly induced CYP1A activity and increased levels of DNA adducts in livers of juvenile chinook salmon. Evidence for increases in biliary levels of FACs was also observed in juvenile chinook salmon at 6 d following exposure to PAHs. Levels of PAHs in the body and liver were not measured, because unlike PCBs, PAHs are rapidly metabolized by the liver and their metabolites can be detected in the bile of exposed animals (Varanasi et al. 1989). Our findings are largely consistent with previous laboratory studies showing that biliary FACs, CYP1A activity and DNA adducts are sensitive and responsive to PAH exposure (Stein et al. 1992, Collier and Varanasi 1991). Although the increase in biliary FAC levels due to exposure to PAHs at 6 d post exposure was higher than that for any of the other treatment groups, it was not statistically significant. This low response of FACs to PAH exposure was not expected. Species-specific differences may be a factor, as previous extensive studies of the time- and dose-responsiveness of biliary FACs in flatfish have shown the sensitivity of this measure to PAH exposure. However, without additional information on the time-course response of FACs in juvenile chinook salmon exposed to PAHs, any further explanation of the findings would be speculative.

Juvenile chinook salmon exposed to PCBs had elevated body and liver levels of PCBs as well as induction of hepatic CYP1A activity. This is consistent with other studies showing similar CYP1A induction by PCB mixtures (Safe 1994; Collier and Varanasi, 1991). Evidence of HCBD exposure was detected as increased concentrations of HCBD in liver and whole body of juvenile salmon. Unlike PCBs or PAHs, no evidence of hepatic CYP1A induction or altered biliary FACs was observed, upon exposure to HCBD, at any time during the 60 d monitoring period. It was not surprising that the biochemical measurements made in this study did not show any response following HCBD exposure because HCBD was not expected to induce a response in the biomarkers measured. The types of chemicals that induce a response in the three biomarkers measured have very different chemical structures than HCBD. Moreover, we are not aware of any other validated biochemical responses which could be expected to change following acute exposure to HCBD in fish. It is possible that there may have been kidney damage resulting from the HCBD exposure, as this compound is known to be nephrotoxic in mammals (Nakagawa et al. 1998). Histopathological examination of fixed kidney tissue from HCBD-exposed salmon could address this question.

The biochemical responses to the sediment extract exposures were consistent with the observations made with individual or model mixtures of chemical compounds. For example, significant increases in tissue levels of PCBs and hepatic CYP1A activity were observed in juvenile chinook salmon exposed to single injection of either Hylebos sediment extract. Because CYP1A activity was significantly elevated at 20 d post exposure in fish treated with PCBs, but not with PAHs, the elevated CYP1A response at the later time points in the extract treated fish is likely due to PCBs or other compounds similar in structure and persistence in fish tissues as PCBs that are present in the Hylebos Waterway sediment extracts. Similarly, because fish exposed to either of the two extracts exhibited elevated DNA adduct levels at 20 d post exposure in the same manner as those exposed to PAHs only, this elevated response was likely a consequence of PAH exposure. Biliary FACs were not elevated at the earliest time period monitored (6 d post exposure) following exposure to either HWSE. While this lack of a FAC response was not expected, as discussed above it is not appropriate to speculate as to the reason for this lack of response. The overall responses from exposure to either of the HWSEs (HWSE-M and HWSE-P) were similar, which is consistent with the similarity in the dosage and composition of chemical contaminants in these two extracts. Furthermore, the similarity in the response to the two extracts and lack of response to the reference sediment extract (NQSE) supports the conclusion that it is the chemical contaminants present in the Hylebos Waterway sediments, and not naturally occurring compounds, that were responsible for the increases in DNA adducts and CYP1A activity. The apparently higher HCBD concentration in whole body tissue observed at 6 d in the HWSE-M group compared to the HWSE-P group may be due to the fact that the levels being quantitated are approaching the detection limit, making accurate quantitation more difficult.

Overall, the current findings show that each class of toxic chemicals characteristic of the Hylebos Waterway produced a signature response from the suite of biochemical and chemical endpoints employed in this study. When we evaluated the responses of juvenile chinook salmon exposed to the complex mixture of contaminants in the two Hylebos Waterway sediment extracts, the collective biomarker and chemical endpoint response generally reflected the contribution of the individual component classes of this complex contaminant mixture. Thus, the integrated use of a suite of measurements allowed for identification of the compound classes likely responsible for specific responses. This information increases our ability to interpret chemical exposure history of juvenile salmon from the Hylebos Waterway.

Compounds such as HCBD, PCBs, and PAHs, characteristic of the Hylebos Waterway, persist for an extended period after exposure.

Measures of chemical concentrations in tissues of exposed animals explicitly reveal the persistence and magnitude of exposure to chemical contaminants that are not easily degraded by biological processes, and provide information for linking biological effects to chemical contaminants. In the current study, when juvenile chinook salmon were exposed to PCBs at a dose equivalent to 20% of the 96 hr LD_{50}, this exposure was evident in liver and whole body PCB levels at the end of the 60 d experimental period. At this time point, whole body PCB concentrations had declined to approximately 30% of maximum levels measured, and liver PCB concentration declined to 5% of the levels observed at 6 d post exposure. These findings demonstrate that appreciable levels of PCBs persist in the tissues for a significant period of time, weeks after the exposure from external sources is terminated. On the basis of these findings, it is evident that the potential for biological effects from PCB exposure may also persist for an extended period. This conclusion is supported by the observation of induced CYP1A activities at 60 d in the PCB treated fish.

Persistence of PCBs in tissues was also observed in fish receiving either of the Hylebos Waterway sediment extracts. Elevated liver PCB concentrations were observed in fish exposed to either HWSE-M or HWSE-P sampled at 6 d post exposure, and body concentrations of PCBs were significantly elevated for at least 20 d post exposure. The lower magnitude and the apparent shorter duration of the response (based on the tissue concentrations) in fish exposed to sediment extracts are expected with a single injection of much lower dose of PCBs present in either of the Hylebos Waterway sediment extracts (28 to 32 µg PCBs/kg fish) compared to fish exposed to PCBs only (28,000 µg PCBs/kg fish). The concentrations of PCBs measured in liver tissues of the extract exposed fish were comparable to levels observed in juvenile chinook and chum salmon collected in the field study (Round I). Thus, it is likely that juvenile salmon may experience the biological consequences of a short-term exposure to PCBs for at least 3 weeks after leaving the Hylebos Waterway.

Elevated HCBD levels persisted in whole body and liver tissue of juvenile salmon exposed to HCBD only, but not to the same extent as PCBs. Whole body HCBD concentrations were significantly elevated through 20 d, and by 60 d HCBD levels were still elevated but no longer statistically different (at the $p<0.05$ level) from controls. The decline in HCBD levels was even more rapid in liver tissue. Hepatic HCBD concentrations were significantly elevated at 6 and 20 d post exposure, but were approaching the limits of detection by 60 d post exposure in HCBD injected fish. Fish injected with either of the two extracts also exhibited evidence of HCBD exposure at 6 d post injection; however, in contrast to the HCBD only treated group, HCBD was not detectable by 20 d post exposure. These findings showing that HCBD levels

declined more rapidly than PCB levels suggest that either metabolism, excretion or both metabolism and excretion of HCBD was greater in juvenile chinook salmon.

The persistence of the hepatic CYP1A activity and increased DNA adduct levels observed in fish exposed to sediment extracts from the Hylebos Waterway can be largely attributed to specific classes of compounds based on the responses observed from exposure to PCBs or PAHs individually. For example, CYP1A activity remained elevated for up to 20 d post exposure in juvenile salmon exposed to sediment extracts from the Hylebos Waterway, in the same manner as in fish exposed to PCBs only, thus indicating that the persistence of CYP1A response in this study is likely due to exposure to PCBs. Other substances, such as dioxins and dibenzofurans, could also potentially be contributing to such induction. However, these types of compounds were not analyzed in the current set of studies. Similarly, hepatic PAH-DNA adduct levels in sediment extract treated fish also remained significantly elevated at 20 d post exposure at about 3 times as high as the levels observed in the NQSE group. This finding suggests that exposure to PAHs results in persistent levels of PAH-DNA adducts for 1 - 3 weeks after a short-term exposure in juvenile salmon. This finding is consistent with studies with English sole showing that DNA adducts in liver persist for > 3 weeks (Stein et al. 1993).

Overall, these findings support the conclusion that chemical tissue burdens of chlorinated contaminants as well as biochemical responses will likely persist after juvenile chinook salmon leave the estuary and exposure to toxic chemicals from sources in the Hylebos Waterway ceases. Furthermore, the collective findings for CYP1A and DNA-adducts suggest the potential for effects from exposure to PCBs and PAHs, and that juvenile salmon may experience the biological consequences of a short-term exposure to these toxic compounds which can persist for at least 1 - 3 weeks after leaving the Hylebos Waterway.

Responses of juvenile chinook salmon exposed to sediments extracts from the Hylebos Waterway in the laboratory were comparable to those observed in juvenile chinook and chum salmon from the Hylebos Waterway.

When we evaluated the biomarker responses due to exposure to a mixture of PAHs, PCBs, and HCBD in the laboratory, as represented by sediment extracts of Hylebos Waterway sediments, the collective response was comparable to the responses observed in juvenile salmon sampled directly from the Hylebos Waterway. The current findings showed that total PCBs and HCBD concentrations in liver of sediment-extract injected fish observed at 6 d post injection were similar to those measured in salmon captured in the Hylebos Waterway during Round I of the Fish Injury Study (Collier et al. 1998). Thus, biomarker responses of juvenile salmon injected with a single dose of the sediment extracts in the laboratory reflected the exposure of naturally outmigrating juvenile salmon to chemical contaminants present in the Hylebos

Waterway. More importantly, the current laboratory results suggest that a relationship exists between alterations in the CYP1A and DNA adduct responses and exposure of juvenile chinook salmon to chemical contaminants present in this Waterway. Furthermore, the findings from this study indicated that exposure to chemical contaminants from the Hylebos Waterway elicit chemical and biochemical changes which can persist for up to 3 weeks after exposure ceases. The findings from the disease challenge (Part 1) and growth (Part 2) experiment components of Round II of the Hylebos Fish Injury Study also indicated that juvenile salmon exposed to the same test solutions used in this study exhibited impaired growth and increased disease susceptibility (Arkoosh et al. 1998a, Casillas et al. 1998). In previous studies, fish naturally exposed to a similar suite of contaminants from the Duwamish Waterway also exhibited immune dysfunction (Arkoosh et al. 1991, 1994) as well as increased disease susceptibility (Arkoosh et al. 1998b) and impaired growth (Casillas et al. 1995b). Hence, we conclude that juvenile salmon from the Hylebos Waterway have an increased risk of deleterious biological effects (altered immune function, increased disease susceptibility, and reduced growth) due to exposure to the chemical contaminants present in this Waterway.

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Table 1. Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway. Concentrations of selected aromatic hydrocarbons, chlorinated butadienes, pesticides, and polychlorinated biphenyls in the methylene chloride fraction of an extract of sediment from the Nisqually River (NQSE) that was used in the laboratory experiment.

Analyte	ng/g sediment[a]	Analyte	ng/g sediment
Aromatic Hydrocarbons		Pesticides	
naphthalene	1	hexachlorobenzene	< 0.02
2-methylnaphthalene	1	lindane (gamma-BHC)	< 0.039
1-methylnaphthalene	1	heptachlor	0.035
biphenyl	< 0.2	aldrin	< 0.029
2,6-dimethylnaphthalene	1	heptachlorepoxide	< 0.024
acenaphthylene	< 0.2	oxychlordane	< 0.03
acenaphthene	< 0.3	trans-chlordane	0.16
2,3,5-trimethylnaphthalene	2	nonachlor-III	n/a
fluorene	< 0.3	alpha-chlordane	< 0.02
phenanthrene	2	trans-nonachlor	< 0.018
anthracene	< 0.2	cis-nonachlor	< 0.028
1-methylphenanthrene	1	dieldrin	< 0.023
fluoranthene	1	mirex	< 0.016
pyrene	1	o,p'-DDE	< 0.04
benz[a]anthracene	0.4	p,p'-DDE	0.32
chrysene	0.8	o,p'-DDD	< 0.038
benzo[b]fluoranthene	0.5	p,p'-DDD	0.098
benzo[k]fluoranthene	< 0.2	o,p'-DDT	< 0.015
benzo[e]pyrene	0.4	p,p'-DDT	0.056
benzo[a]pyrene	< 0.2		
perylene	2	PCBs	
indeno[1,2,3-cd]pyrene	< 0.2	trichlorobiphenyl - 18	< 0.053
dibenz[a,h]anthracene	< 0.2	trichlorobiphenyl - 28	0.13
benzo[g,h,i]perylene	0.3	tetrachlorobiphenyl - 44	0.11
dibenzothiophene	< 0.2	tetrachlorobiphenyl - 52	< 0.037
		tetrachlorobiphenyl - 66	0.067
		pentachlorobiphenyl - 101	0.039
Chlorinated Butadienes[b]		pentachlorobiphenyl - 105	< 0.023
Trichlorobutadiene	<0.05	pentachlorobiphenyl - 118	< 0.025
Tetrachlorobutadiene	<0.05	hexachlorobiphenyl - 128	< 0.019
Pentachlorobutadiene	<0.05	hexachlorobiphenyl - 138	0.19
Hexachlorobutadiene	<0.05	hexachlorobiphenyl - 153	0.13
		heptachlorobiphenyl - 170	0.084
		heptachlorobiphenyl - 180	0.14
		heptachlorobiphenyl - 187	0.037
		octachlorobiphenyl - 195	< 0.013
		nonachlorobiphenyl - 206	0.017
		decachlorobiphenyl - 209	0.088

[a] Concentrations were calculated on a wet weight basis where 1 µl of the bulk extract corresponds to 0.2 g of sediment.

[b] Concentrations of the butadienes were calculated using GC/MS total ion current areas and a response factor of 1 relative to the internal standard.

Table 2. Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway. Concentrations of selected aromatic hydrocarbons, chlorinated butadienes, pesticides, and polychlorinated biphenyls in the methylene chloride fraction of an extract of sediment from the Hylebos Waterway (HWSE-M) that was used in the laboratory experiment.

Analyte	ng/g sediment[a]	Analyte	ng/g sediment
Aromatic Hydrocarbons		Pesticides	
naphthalene	46	hexachlorobenzene	140
2-methylnaphthalene	22	lindane (gamma-BHC)	3.2
1-methylnaphthalene	14	heptachlor	5
biphenyl	8	aldrin	1.6
2,6-dimethylnaphthalene	14	heptachlorepoxide	30
acenaphthylene	3	oxychlordane	1.2
acenaphthene	25	trans-chlordane	6.5
2,3,5-trimethylnaphthalene	9	nonachlor-III	n/a
fluorene	32	alpha-chlordane	2.6
phenanthrene	130	trans-nonachlor	5.0
anthracene	41	cis-nonachlor	1.1
1-methylphenanthrene	17	dieldrin	1.3
fluoranthene	180	mirex	2.1
pyrene	150	o,p'-DDE	1.7
benz[a]anthracene	65	p,p'-DDE	0.46
chrysene	99	o,p'-DDD	7.2
benzo[b]fluoranthene	72	p,p'-DDD	4.1
benzo[k]fluoranthene	52	o,p'-DDT	9.9
benzo[e]pyrene	49	p,p'-DDT	< 0.0097
benzo[a]pyrene	48		
perylene	18	PCBs	
indeno[1,2,3-cd]pyrene	28	trichlorobiphenyl - 18	2.5
dibenz[a,h]anthracene	9	trichlorobiphenyl - 28	5.8
benzo[ghi]perylene	31	tetrachlorobiphenyl - 44	2.3
dibenzothiophene	34	tetrachlorobiphenyl - 52	4.6
		tetrachlorobiphenyl - 66	5.1
		pentachlorobiphenyl - 101	4.0
Chlorinated Butadienes[b]		pentachlorobiphenyl - 105	1.1
Trichlorobutadiene	520	pentachlorobiphenyl - 118	4.8
Tetrachlorobutadiene	590	hexachlorobiphenyl - 128	1.8
Pentachlorobutadiene	170	hexachlorobiphenyl - 138	4.7
Hexachlorobutadiene	130	hexachlorobiphenyl - 153	4.9
		heptachlorobiphenyl - 170	2.6
		heptachlorobiphenyl - 180	10
		heptachlorobiphenyl - 187	2.9
		octachlorobiphenyl - 195	2.7
		nonachlorobiphenyl - 206	15
		decachlorobiphenyl - 209	34

[a] Concentrations were calculated on a wet weight basis where 1 µl of the bulk extract corresponds to 0.2 g of sediment.

[b] Concentrations of the butadienes were calculated using GC/MS total ion current areas and a response factor of 1 relative to the internal standard.

Table 3. Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway. Concentrations of selected aromatic hydrocarbons, chlorinated butadienes, pesticides, and polychlorinated biphenyls in the pentane fraction of an extract of sediment from the Hylebos Waterway (HWSE-P) that was used in the laboratory experiment.

Analyte	ng/g sediment[a]
Aromatic Hydrocarbons	
naphthalene	26
2-methylnaphthalene	18
1-methylnaphthalene	10
biphenyl	6
2,6-dimethylnaphthalene	10
acenaphthylene	0.9
acenaphthene	28
2,3,5-trimethylnaphthalene	28
fluorene	28
phenanthrene	140
anthracene	47
1-methylphenanthrene	10
fluoranthene	170
pyrene	170
benz[a]anthracene	23
chrysene	33
benzo[b]fluoranthene	6
benzo[k]fluoranthene	5
benzo[e]pyrene	9
benzo[a]pyrene	10
perylene	2
indeno[1,2,3-cd]pyrene	0.3
dibenz[a,h]anthracene	< 0.02
benzo[ghi]perylene	1.0
dibenzothiophene	12
Chlorinated Butadienes[b]	
Trichlorobutadiene	480
Tetrachlorobutadiene	450
Pentachlorobutadiene	160
Hexachlorobutadiene	150

Analyte	ng/g sediment
Pesticides	
hexachlorobenzene	110
lindane (gamma-BHC)	2.0
heptachlor	0.8
aldrin	< 0.06
heptachlorepoxide	21
oxychlordane	< 0.07
trans-chlordane	< 0.06
nonachlor-III	< 0.06
alpha-chlordane	2.0
trans-nonachlor	5.0
cis-nonachlor	0.4
dieldrin	2.0
mirex	2.0
o,p'-DDE	1.0
p,p'-DDE	0.4
o,p'-DDD	20
p,p'-DDD	1.0
o,p'-DDT	< 0.1
p,p'-DDT	< 0.1
PCBs	
trichlorobiphenyl - 18	17
trichlorobiphenyl - 28	6.0
tetrachlorobiphenyl - 44	1.0
tetrachlorobiphenyl - 52	3.0
tetrachlorobiphenyl - 66	< 0.08
pentachlorobiphenyl - 101	3.0
pentachlorobiphenyl - 105	< 0.06
pentachlorobiphenyl - 118	< 0.07
hexachlorobiphenyl - 128	0.8
hexachlorobiphenyl - 138	2.0
hexachlorobiphenyl - 153	4.0
heptachlorobiphenyl - 170	1.0
heptachlorobiphenyl - 180	9.0
heptachlorobiphenyl - 187	2.0
octachlorobiphenyl - 195	2.0
nonachlorobiphenyl - 206	12
decachlorobiphenyl - 209	31

[a] Analyte concentrations calculated on a sediment wet weight basis where 1 µl of the bulk extract corresponds to 0.4 g of sediment.

[b] Concentrations of the butadienes were calculated using GC/MS total ion current areas and a response factor of 1 relative to the internal standard.

Table 4. Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway. High molecular weight hydrocarbons that comprise the PAH model mixture. The compounds were combined in acetone at the same ratios as they were present in the sediment at station 24 of the Hylebos Waterway to a concentration equivalent to 400 g sediment extracted per ml of acetone.

PAH Analyte and concentration (ng/µl)			
Fluoranthene	5000	Benz[k]fluoranthene	1920
Pyrene	460	Benzo[a]pyrene	1540
Benz[a]anthracene	1640	Indeno[1,2,3-cd]pyrene	2400
Chrysene	3200	Dibenz[a,h]anthracene	220
Benz[b]fluoranthene	5000	Benzo[ghi]perylene	1880

Table 5. Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway. Weekly mortality of juvenile chinook salmon exposed to various sediment extracts or model mixtures in Round II biomarker experiment.

	Week										
Treatment	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**	**% Mort.**
Acetone/Emulphor	0	0	4	9	5	0	0	0	0	18	6.0
NQSE	9	7	4	3	4	0	0	0	0	27	9.7
HWSE-M	3	6	0	25	19	0	0	0	0	53	17.7
HWSE-P	0	1	4	5	3	4	6	12	0	35	19.2
HCBD	6	2	11	7	4	5	2	10	0	47	15.7
PCBs	9	2	4	4	2	0	5	14	13	53	17.7
PAHs	6	1	6	0	0	2	1	6	0	22	7.3

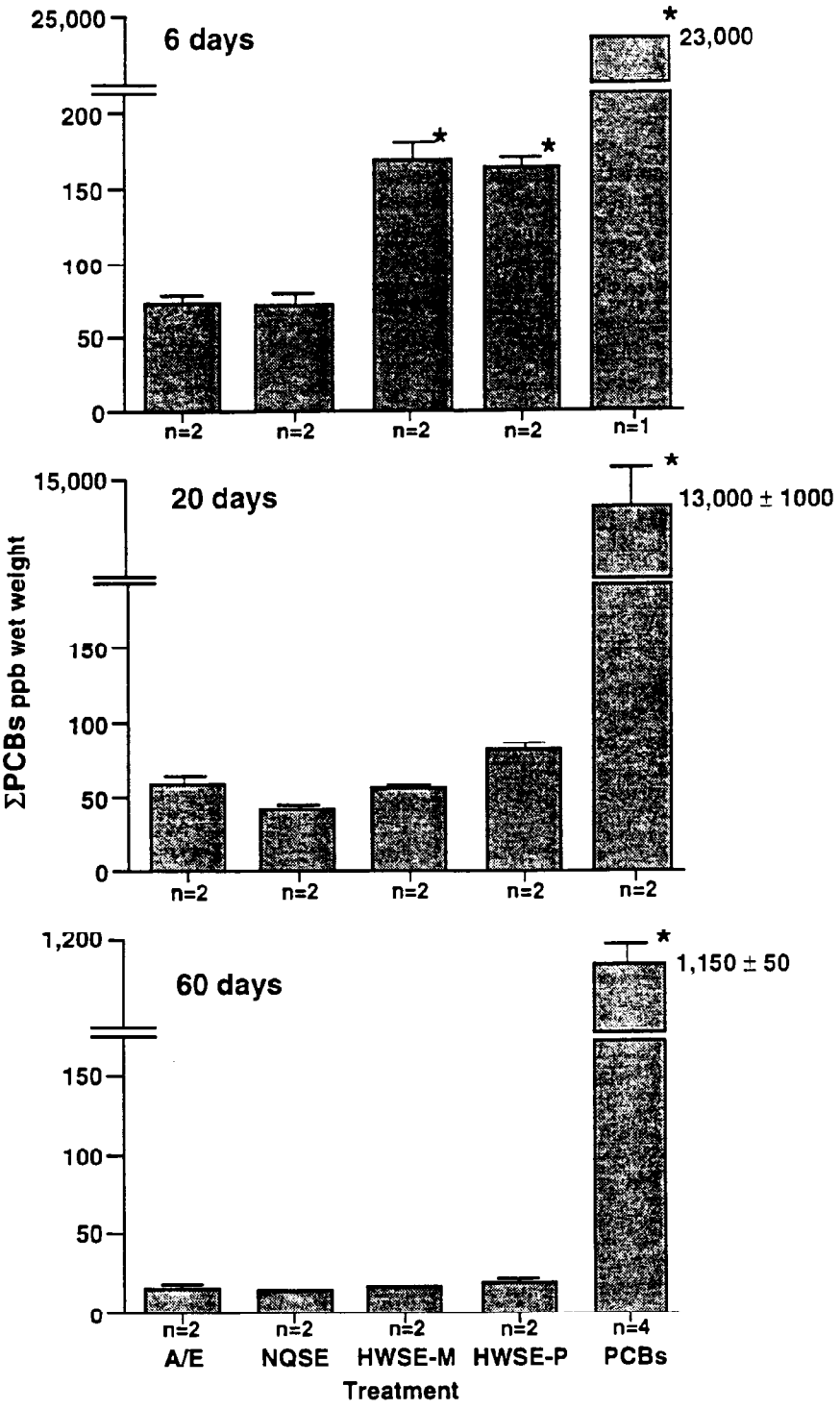

Figure 1. Hepatic ΣPCBs in juvenile chinook salmon exposed to selected chemical contaminants. Values are mean ± SE. n = number of analyses. * = Number is significantly different from A/E and NQSE groups. ppb = parts per billion. A/E = acctone/ emulphor injection vehicle, NQSE = Nisqually sediment extract, HWSE-M = Hylebos Waterway sediment extract- sediment extracted with methylene chloride, HWSE-P = Hylebos Waterway sediment extracted with pentane, PCBs = polychlorinated biphenyls.

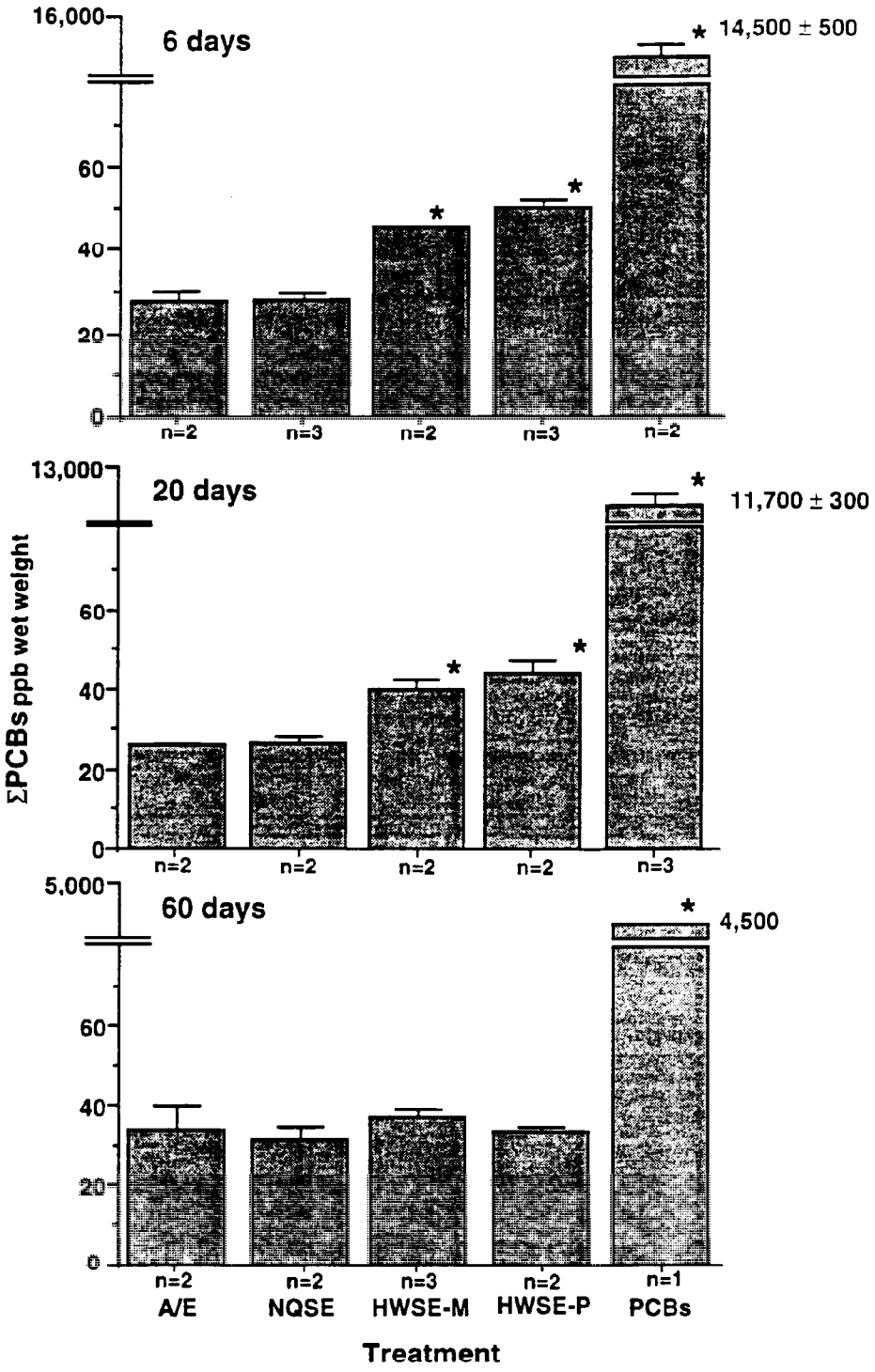

Figure 2. Whole body ΣPCBs in juvenile chinook salmon exposed to selected chemical contaminants. Values are mean ± SE. n = number of analyses. * = Value is significantly different from A/E and NQSE groups. ppb = parts per billion. A/E = acetone/ emulphor injection vehicle, NQSE = Nisqually sediment extract, HWSE-M = Hylebos Waterway sediment extracted with methylene chloride, HWSE-P = Hylebos Waterway sediment extracted with pentane, PCBs = polychlorinated biphenyls.

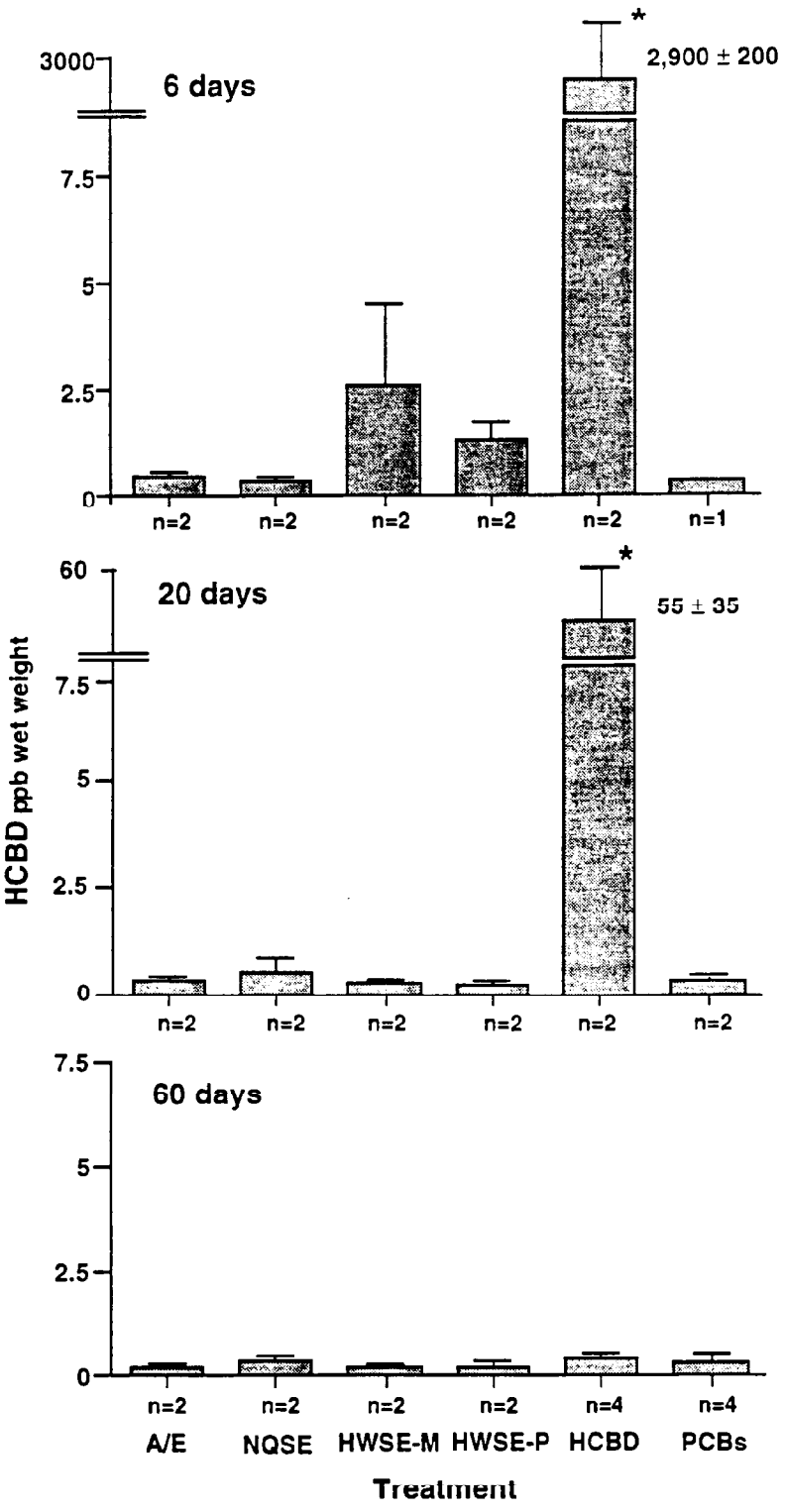

Figure 3. Hepatic HCBD concentrations in juvenile chinook salmon exposed to selected chemical contaminants. Values are mean ± SE. n = number of analyses. * = Value is significantly different from A/E and NQSE groups. ppb = parts per billion. A/E = acetone/ emulphor injection vehicle, NQSE = Nisqually sediment extract, HWSE-M = Hylebos Waterway sediment extracted with methylene chloride, HWSE-P = Hylebos Waterway sediment extracted with pentane, HCBD = hexachlorobutadiene. PCBs = polychlorinated biphenyls.

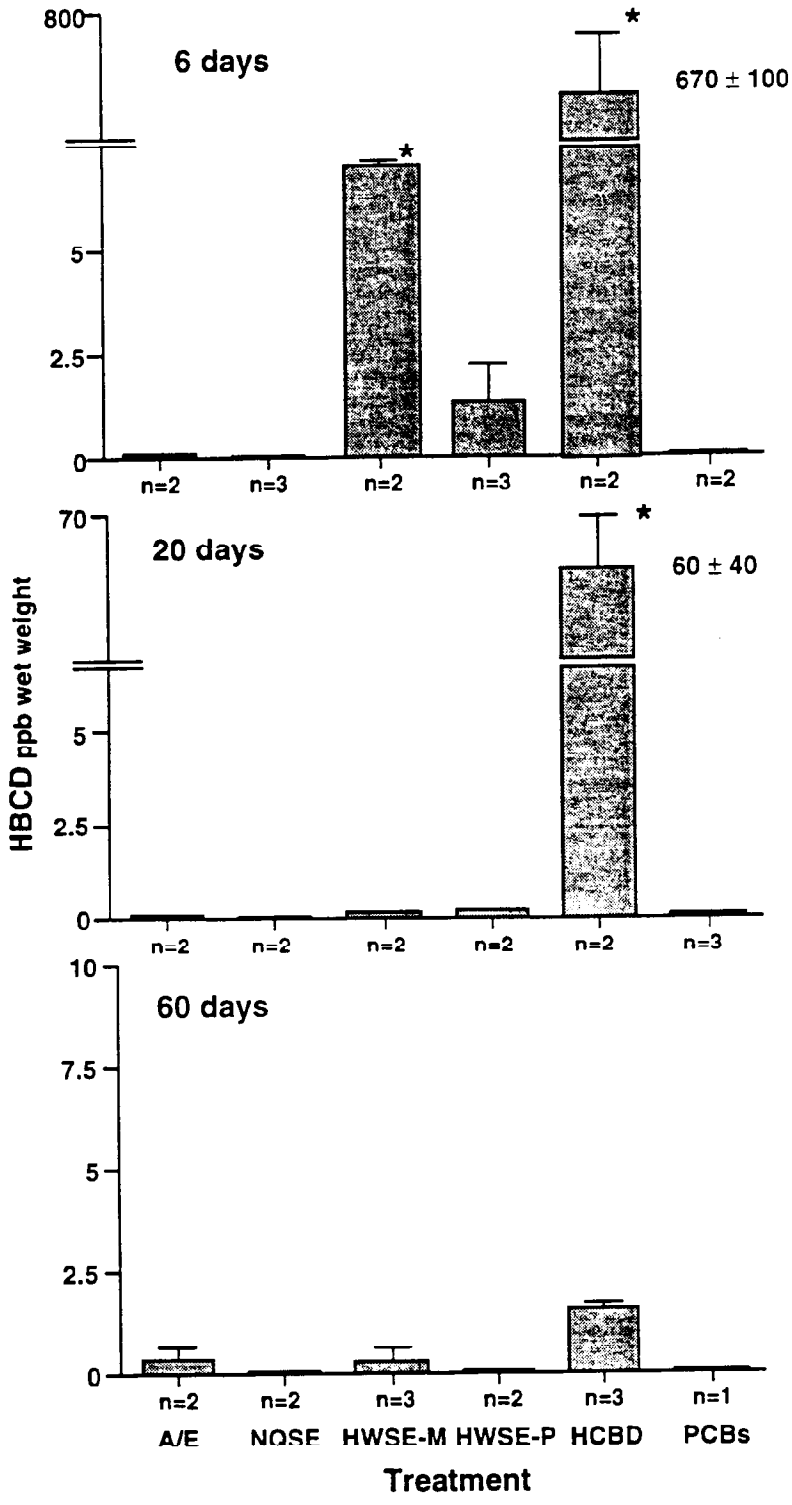

Figure 4. Whole body HCBD concentrations in juvenile chinook salmon exposed to selected chemical contaminants. Values are mean ± SE. n = number of analyses. * = Value is significantly different from A/E and NQSE groups. ppb = parts per billion. A/E = acetone/ emulphor injection vehicle, NQSE = Nisqually sediment extract, HWSE-M = Hylebos Waterway sediment extracted with methylene chloride, HWSE-P = Hylebos Waterway sediment extracted with pentane. HCBD = hexachlorobutadiene. PCBs = polychlorinated biphenyls.

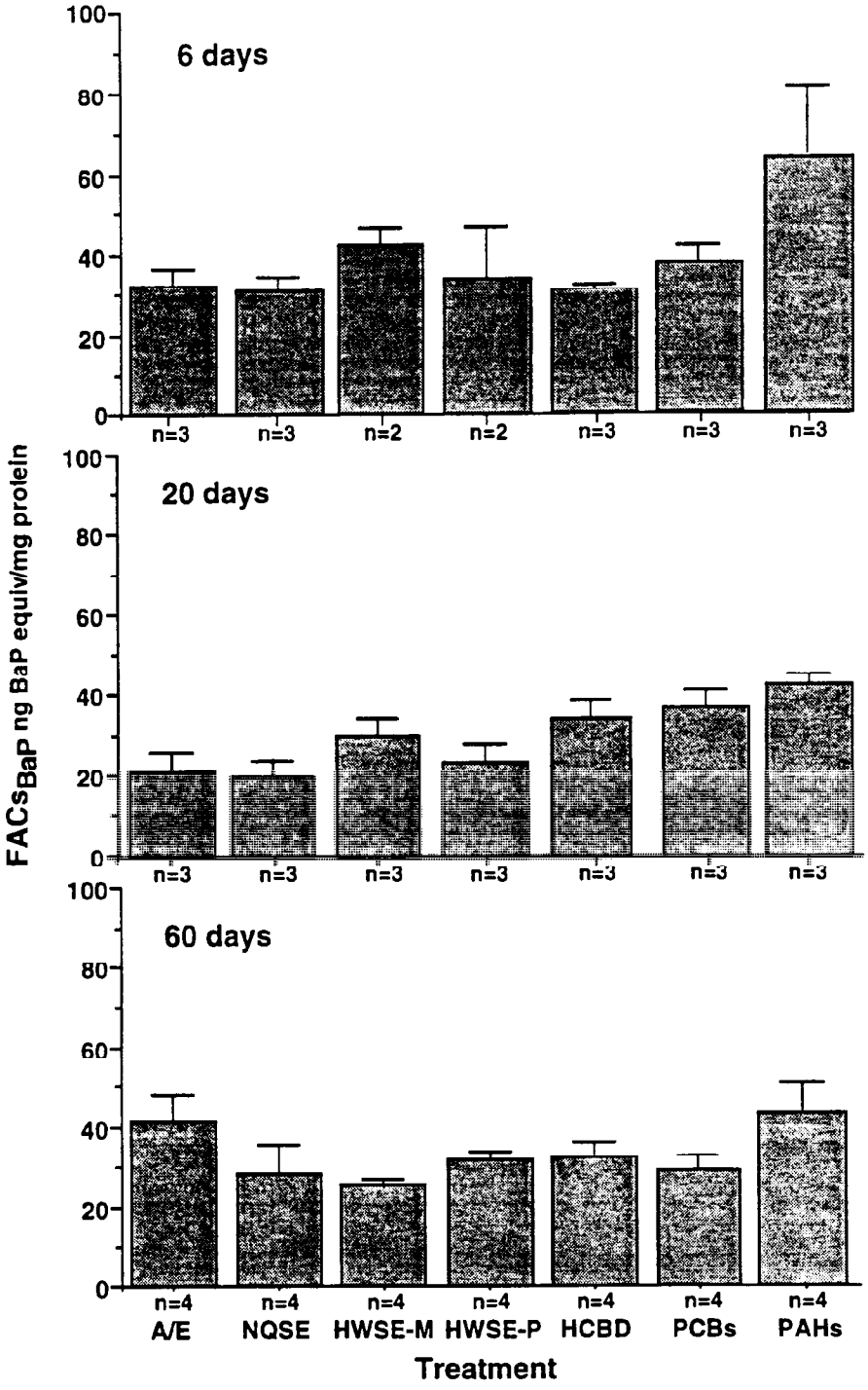

Figure 5. Biliary FACs in juvenile chinook salmon exposed to selected chemical contaminants. Values are mean ± SE. n = number of analyses. ppb = parts per billion. A/E = acetone/ emulphor injection vehicle, NQSE = Nisqually sediment extract, HWSE-M = Hylebos Waterway sediment extract- sediment extracted with methylene chloride, HWSE-P = Hylebos Waterway sediment extracted with pentane, PCBs = polychlorinated biphenyls.

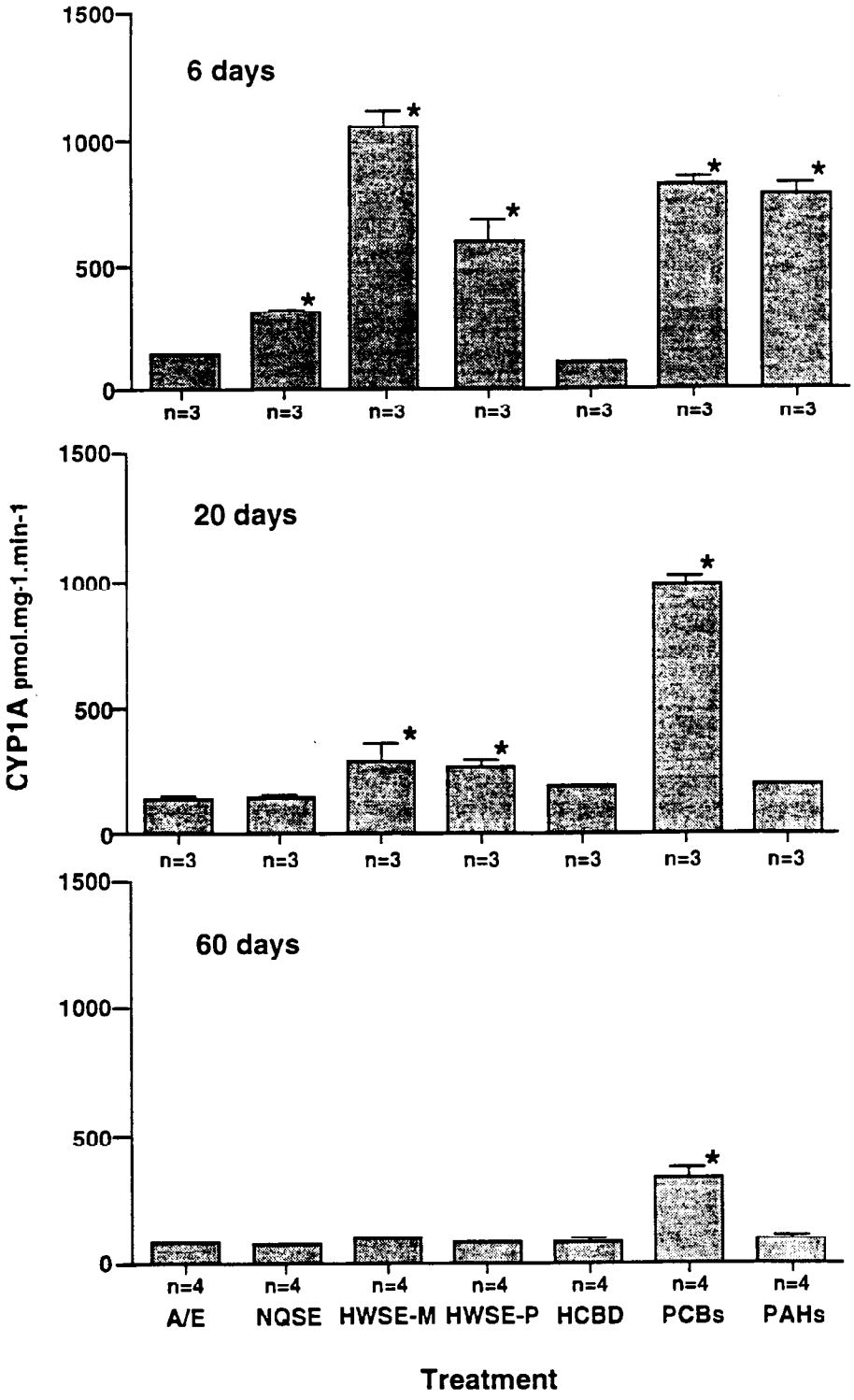

Figure 6. Hepatic cytochrome P4501A (CYP1A) activity in juvenile chinook salmon exposed to selected chemical contaminants. Values are mean ± SE. n = number of analyses. * = Value is significantly different from A/E and NQSE groups. ppb = parts per billion. A/E = acetone/ emulphor injection vehicle, NQSE = Nisqually sediment extract, HWSE-M = Hylebos Waterway sediment extracted with methylene chloride, HWSE-P = Hylebos Waterway sediment extracted with pentane, HCBD = hexachlorobutadiene. PCBs = polychlorinated biphenyls. PAHs = polynuclear aromatic hydrocarbon.

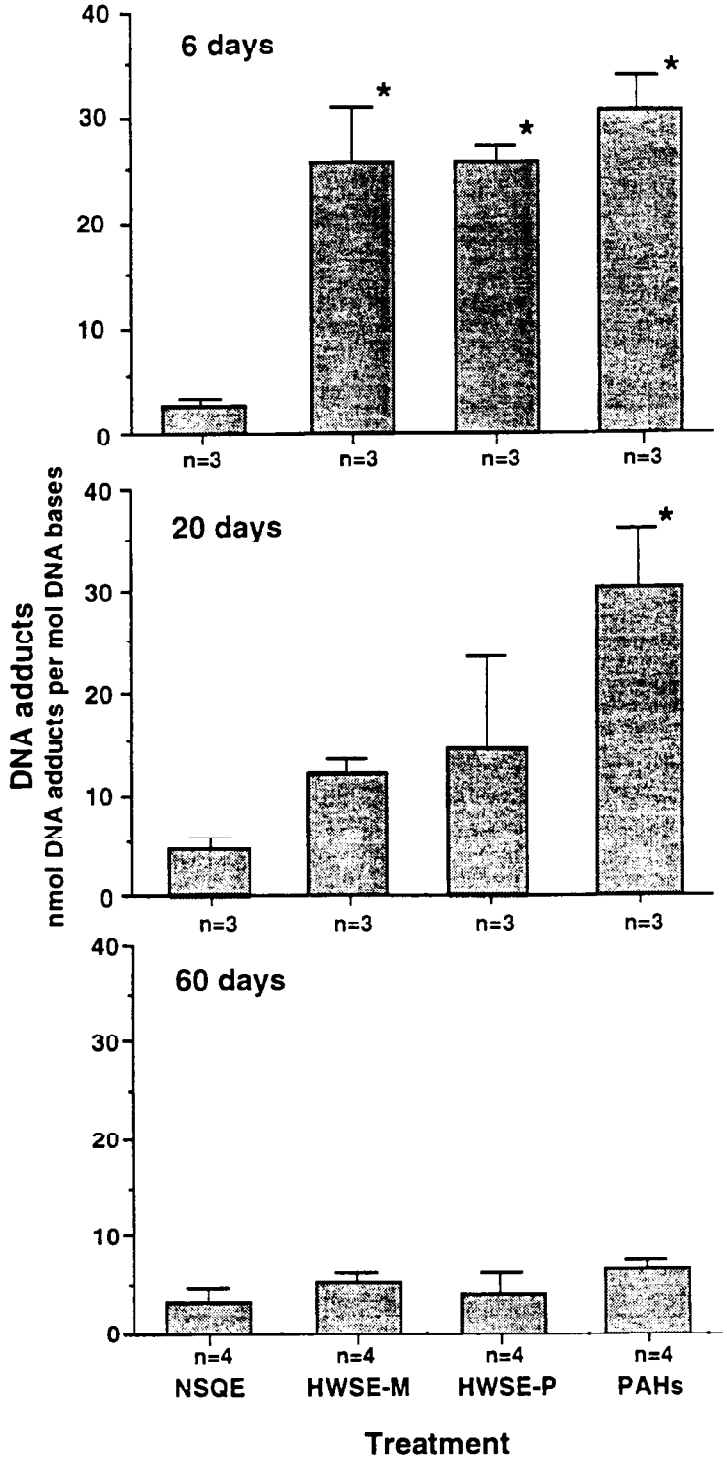

Figure 7. Hepatic DNA adducts in juvenile chinook salmon exposed to selected chemical contaminants. Values are mean ± SE. n = number of analyses. * = Value is significantly different from A/E and NQSE groups. ppb = parts per billion. NQSE = Nisqually sediment extract, HWSE-M = Hylebos Waterway sediment extracted with methylene chloride, HWSE-P = Hylebos Waterway sediment extracted with pentane, PAHs = polynuclear aromatic hydrocarbons.

Hylebos Fish Injury Study - Round II, Part 3
Individual Data and Quality Assurance Results
CASE NARRATIVE

Juvenile Salmon Time Response Study

Laboratory Studies

Time-Response (Biomarker) Study:

General Comments

The time-response experiment started on July 9, 1997. Juvenile chinook from Soos Creeks Hatchery brought to the Mukilteo facility were sorted by size (85±2 mm) a day prior to the experiment. Groups of three hundred fish each were injected with one of the following solutions, acetone/Emulphor, HWSE-M, PAHs, PCBs and HCBD. Only 279 fish were injected with NQSE and 182 fish were injected with HWSE-P because of insufficient NQSE and HWSE-P. Fish were sedated with (5 mg/L) metomidate in 5-gallon buckets (~ 20 fish at a time), lengths and weights were recorded, then test solution was administered at 1.5 µL/g body wt. A total of 1961 fish were injected. After injection, fish were transferred to designated 750 gal. tanks equipped with flowing filtered seawater (Fig. A). Injections were completed in one day. Experimental fish were fed twice daily to satiation, except on Sunday.

Sampling Protocols

The first sampling to collect tissues and fluids for analyses of biomarker responses was conducted at 6 d, and the second at 20 d post injection. At each of these two time points, three composites (20 fish/comp.) of livers and bile were collected for CYP1A, DNA adducts (livers) and FACs (bile). Three composites (5 fish/comp.) of livers and whole gutted bodies were collected separately for CH analysis. This sampling protocol was not applied to the HWSE-P group due to the limited number of fish injected with this extract. For this group, three composites (10 fish/comp.) of livers and bile were collected for CYP1A, DNA adducts (livers) and FACs (bile). Three composites (5 fish/comp.) of livers and whole gutted bodies were collected separately for CH analysis.

Mid-way through the experiment, on a routine fish check, we discovered that some fish in several tanks disappeared and the loss was not a result of mortality. This fish loss was probably due to fish escaping either through the water standpipe or the cover gaps. When it became apparent that insufficient numbers of fish from several treatments would be available for the 60 d sampling time-point, we decided to change the sampling schedule. For example, on August 8, 1997 (33 d post injection), only 39 fish were sampled from each of the following treatments HWSE-M and NQSE. Three composites (10 fish/comp) of livers and bile each were collected for CYP1A, DNA adducts (livers) and FACs (bile). An additional three composites (3 fish/comp) of livers and whole gutted bodies were pooled separately for CH analysis. On August 13, 1997 (35 d post injection), A/E-injected group was sampled. Three composites (20 fish/comp.) of livers and bile each were collected for CYP1A, DNA adducts (livers) and FACs (bile). Livers and whole gutted bodies from 5 fish were pooled separately for CH analysis. On September 3, 1997 (56 d post injection), HWSE-P-injected group was sampled. Three composites (6 fish/comp.) of livers and bile each were collected for CYP1A, DNA adducts (livers) and FACs (bile). An additional three composites (3 fish/comp) of livers and whole gutted bodies were pooled separately for CH analysis. Fish injected with HCBD were also sampled on this day, five composites (10 fish/comp.) of livers and bile each were collected for CYP1A, DNA adducts (livers) and FACs (bile). An additional three composites (5 fish/comp) of livers and whole gutted bodies were pooled separately for CH analysis.

On September 9, 1997 (60 d post injection), we sampled the two remaining treatment groups (PAHs and PCBs). Three composites (10 fish/comp.) of livers and bile each were collected for CYP1A, DNA adducts (livers) and FACs (bile) from each treatment. An additional three composites (5 fish/comp) of livers and whole gutted bodies were pooled separately for CH analysis.

When the growth study was terminated at 60 d post injection (Aug. 25, 1997), we also collected samples from all seven treatments for biomarker analyses since these fish (in the growth study) were exposed to the same test solutions. For this report, results from the 60 d samples of

the growth study were used to replace the 60 d samples of the time-response (biomarker) study because only two treatment groups (PAHs and PCBs) had sufficient fish for sampling at this time-point.

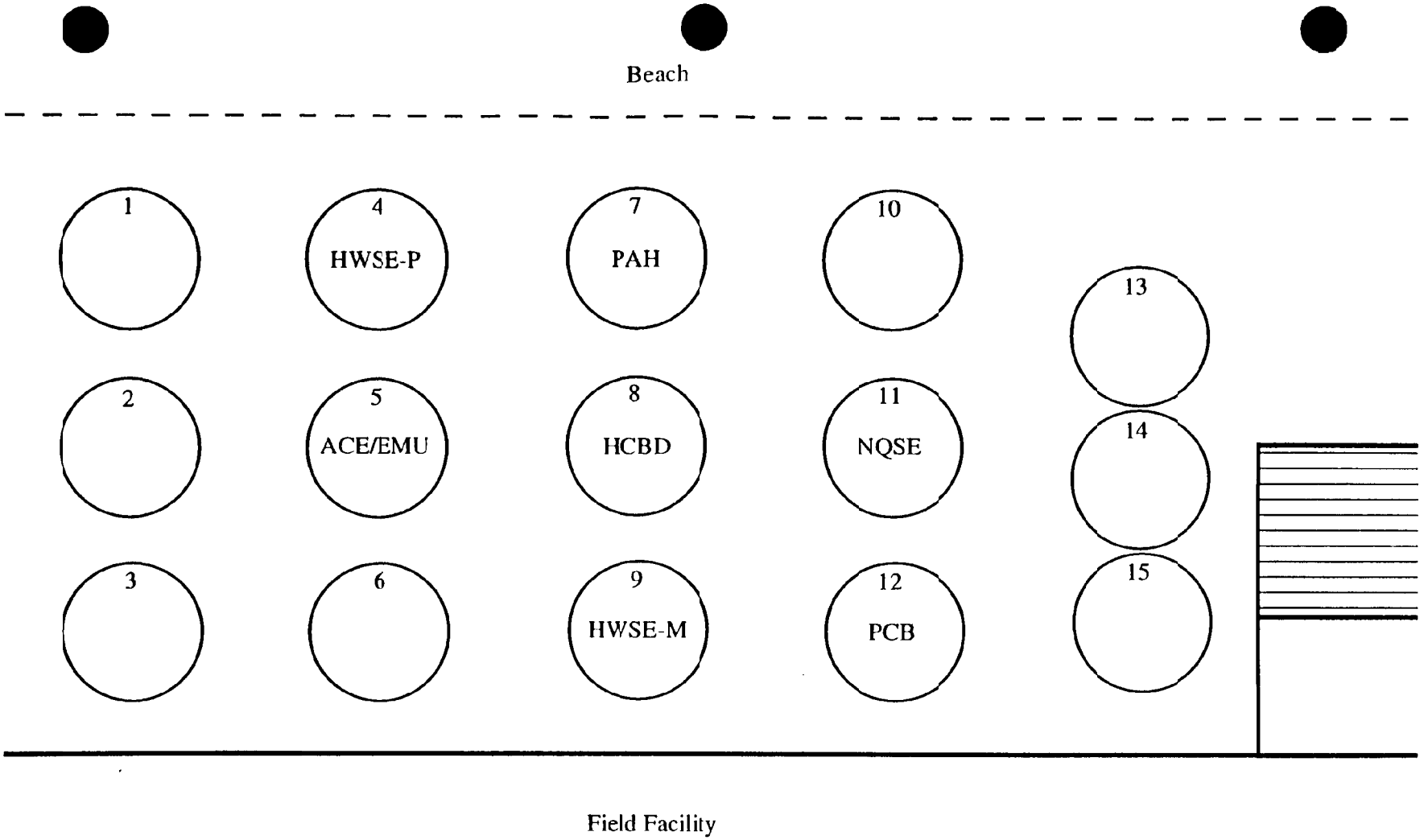

Fig. A Tank layout for Time-response Experiment at Mukilteo Field Facility, Mukilteo, WA.

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon for the injection exposure to acetone/Emulphor.

Treatment: Acetone/Emulphor Tank: 5
Date: 7/9/97

Fish#	Length	Weight
1	87	6.6
2	88	6.0
3	91	7.7
4	91	7.4
5	88	6.2
6	92	8.2
7	86	7.4
8	89	6.7
9	86	7.5
10	89	8.3
11	88	6.1
12	85	5.7
13	85	7.4
14	80	5.7
15	82	5.2
16	81	6.2
17	80	5.0
18	91	6.9
19	94	7.8
20	84	5.2
21	83	4.9
22	82	5.3
23	87	6.5
24	86	5.9
25	88	7.0
26	92	7.5
27	84	4.9
28	81	4.9
29	80	4.5
30	82	5.0
31	85	5.5
32	88	6.5
33	82	5.0
34	86	5.8
35	80	4.9
36	81	4.7
37	92	8.0
38	87	5.7

Fish#	Length	Weight
39	83	5.3
40	83	5.2
41	92	7.9
42	86	6.0
43	90	7.7
44	92	7.3
45	85	5.6
46	89	7.6
47	83	5.6
48	89	6.6
49	88	7.0
50	88	6.3
51	80	4.8
52	89	7.5
53	88	5.2
54	86	6.6
55	84	5.4
56	87	6.5
57	85	6.1
58	83	5.5
59	88	6.0
60	80	5.0
61	81	5.4
62	86	5.8
63	86	6.0
64	86	6.3
65	89	6.5
66	88	6.5
67	88	6.2
68	81	5.1
69	92	7.1
70	85	5.3
71	84	6.2
72	81	5.2
73	87	5.8
74	88	6.0
75	80	5.0
76	83	5.3

Fish#	Length	Weight
77	80	4.7
78	85	6.4
79	81	5.4
80	86	7.1
81	83	6.0
82	88	6.8
83	82	5.1
84	88	7.2
85	93	7.7
86	89	6.8
87	84	5.7
88	90	7.5
89	90	7.4
90	80	5.1
91	89	6.5
92	89	6.7
93	82	5.4
94	88	6.4
95	87	6.8
96	80	4.8
97	87	6.0
98	80	4.6
99	84	5.0
100	88	5.5
101	84	5.3
102	84	5.3
103	87	5.8
104	81	5.0
105	81	5.7
106	83	5.5
107	87	6.0
108	86	6.1
109	88	6.3
110	87	6.5
111	83	5.6
112	88	6.8
113	85	6.5
114	96	8.9

Fish#	Length	Weight
115	86	6.0
116	80	4.3
117	90	7.0
118	82	5.2
119	95	8.2
120	85	6.1
121	80	5.0
122	80	6.6
123	87	5.6
124	87	6.5
125	85	6.2
126	89	6.8
127	93	7.7
128	87	6.5
129	83	5.5
130	85	6.6
131	81	5.5
132	90	7.6
133	92	8.6
134	82	5.8
135	82	6.1
136	86	6.6
137	87	7.0
138	95	8.2
139	82	5.5
140	95	8.2
141	88	6.7
142	83	6.0
143	98	9.2
144	82	5.4
145	85	5.9
146	88	6.2
147	88	6.0
148	82	5.3
149	85	6.8
150	92	7.1

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon for the injection exposure to acetone/Emulphor.

Treatment: Acetone/Emulphor Tank: 5
Date: 7/9/97

Fish#	Length	Weight
151	85	5.6
152	89	7.0
153	89	6.9
154	86	6.4
155	86	5.7
156	81	5.3
157	86	6.2
158	91	7.2
159	93	9.0
160	83	5.4
161	83	5.3
162	83	6.0
163	84	5.2
164	83	5.6
165	84	5.9
166	93	7.8
167	84	5.6
168	94	6.6
169	84	5.6
170	87	5.9
171	89	6.3
172	85	6.1
173	85	5.8
174	87	6.2
175	95	9.0
176	95	9.3
177	81	5.0
178	88	7.0
179	88	6.0
180	85	5.5
181	82	5.7
182	89	7.1
183	93	5.0
184	85	5.7
185	80	5.3
186	90	8.1
187	88	5.9
188	89	6.0

Fish#	Length	Weight
189	80	4.8
190	92	7.4
191	88	6.5
192	88	6.2
193	88	5.7
194	94	8.7
195	89	6.1
196	81	5.5
197	81	5.2
198	86	6.3
199	84	4.9
200	89	6.3
201	84	6.0
202	89	7.5
203	87	6.2
204	90	7.3
205	89	6.5
206	80	5.3
207	91	7.5
208	85	6.5
209	80	5.0
210	87	6.3
211	82	5.2
212	85	6.4
213	89	6.3
214	80	5.0
215	80	4.9
216	89	5.5
217	88	7.3
218	83	6.0
219	82	5.1
220	86	6.6
221	84	5.9
222	83	6.0
223	84	5.5
224	84	6.5
225	86	6.0
226	80	4.7

Fish#	Length	Weight
227	90	6.9
228	88	6.4
229	85	6.4
230	89	6.6
231	87	6.3
232	83	5.9
233	81	5.2
234	85	6.0
235	85	5.6
236	80	4.0
237	94	8.0
238	87	6.3
239	81	4.8
240	84	5.2
241	84	6.2
242	80	5.0
243	89	6.4
244	89	6.9
245	89	7.0
246	85	6.0
247	81	4.8
248	80	5.0
249	83	5.6
250	92	7.6
251	93	7.4
252	85	5.0
253	89	6.6
254	82	5.2
255	84	5.4
256	90	7.1
257	81	5.6
258	91	7.5
259	85	6.0
260	80	5.1
261	85	6.0
262	81	4.9
263	84	6.2
264	86	6.3

Fish#	Length	Weight
265	83	5.4
266	80	4.8
267	90	7.1
268	89	6.9
269	85	5.9
270	82	5.2
271	83	5.5
272	81	5.3
273	82	5.0
274	91	8.0
275	87	6.0
276	83	6.0
277	87	6.9
278	89	6.4
279	85	6.4
280	82	5.4
281	90	7.6
282	80	4.9
283	84	5.4
284	90	6.5
285	88	7.0
286	87	6.0
287	81	4.5
288	82	5.5
289	84	5.7
290	89	6.5
291	83	4.6
292	87	6.2
293	86	6.1
294	88	6.5
295	81	4.9
296	82	5.1
297	85	5.9
298	85	6.1
299	82	5.6
300	90	7.3

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon, exposed to acetone/Emulphor in the Biomarker study, sampled at 6 d post exposure.

Treatment: Acetone/Emulphor Tank: 5
Date: 7/15/97

Fish#	Length	Weight	Fish#	Length	Weight	Fish#	Length	Weight
1	91	8.5	38	83	6.1	75	93	8.3
2	89	7.0	39	86	7.1			
3	80	5.1	40	80	4.3			
4	82	5.7	41	81	5.7			
5	82	5.0	42	85	7.3			
6	90	7.6	43	90	7.1			
7	90	7.6	44	89	6.8			
8	87	7.1	45	81	5.7			
9	89	7.1	46	89	6.8			
10	92	7.9	47	84	5.7			
11	80	5.4	48	90	7.4			
12	81	5.2	49	92	8.1			
13	88	7.1	50	85	6.1			
14	90	7.4	51	87	6.2			
15	80	5.0	52	85	6.4			
16	89	8.4	53	90	8.6			
17	86	6.4	54	85	6.1			
18	85	6.9	55	83	5.7			
19	80	5.7	56	89	6.7			
20	85	6.6	57	88	6.8			
21	85	6.2	58	80	5.8			
22	90	7.5	59	90	7.5			
23	89	6.9	60	81	5.9			
24	90	7.3	61	90	7.3			
25	85	6.1	62	86	6.5			
26	87	6.7	63	89	6.8			
27	85	6.7	64	86	6.7			
28	83	6.2	65	80	6.3			
29	85	6.4	66	81	6.2			
30	86	7.2	67	89	6.8			
31	90	7.3	68	82	5.8			
32	83	5.3	69	86	6.2			
33	97	9.6	70	87	7.2			
34	87	7.5	71	79	5.0			
35	80	5.4	72	85	6.4			
36	86	7.0	73	82	4.9			
37	87	6.3	74	93	8.3			

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon, exposed to acetone/Emulphor in the Biomarker study, sampled at 20 d post exposure.

Treatment: Acetone/Emulphor Tank: 5
Date: 7/29/97

Fish#	Length	Weight
1	92	7.9
2	94	8.9
3	98	10.0
4	94	8.7
5	ND	ND
6	92	8.6
7	92	8.9
8	92	8.2
9	90	7.5
10	87	7.6
11	92	7.4
12	94	8.5
13	83	6.2
14	95	9.7
15	86	6.7
16	94	9.1
17	90	8.3
18	92	8.2
19	93	8.4
20	87	7.3
21	87	5.8
22	90	7.5
23	102	10.6
24	91	7.6
25	85	6.4
26	93	8.3
27	88	7.0
28	86	6.8
29	92	8.1
30	90	7.0
31	98	10.0
32	94	9.3
33	90	7.7
34	90	7.8
35	88	6.7
36	90	7.9
37	98	10.1
38	88	7.0
39	93	9.0
40	100	11.3
41	96	9.2
42	83	5.6
43	92	8.5
44	97	9.2
45	100	9.4
46	87	6.6
47	94	8.7
48	95	8.9
49	90	7.4
50	95	9.4
51	95	9.1
52	90	7.9
53	101	11.3
54	95	9.2
55	92	7.5
56	105	12.0
57	87	6.3
58	96	9.6
59	88	7.4
60	84	8.6
61	91	8.6
62	88	7.5
63	89	7.7
64	90	7.7
65	103	11.4
66	94	9.1
67	90	7.4
68	87	7.8
69	90	7.0
70	87	7.0
71	95	9.5
72	90	7.8
73	97	9.4
74	92	7.8
75	92	7.7
76	84	6.2
77	87	6.8
78	95	9.9
79	85	6.3
80	103	12.0
81	96	9.5
82	92	8.2
83	93	8.8
84	96	9.6
85	97	9.7

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposd to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon, exposed to acetone/Emulphor in the Biomarker study, sampled at 35 d post exposure.

Treatment: Acetone/Emulphor Tank: 5
Date: 8/13/97

Fish#	Length	Weight
1	96	9.5
2	109	14.9
3	96	9.7
4	104	12.1
5	99	11.8
6	100	12.2
7	107	14.1
8	103	11.7
9	95	9.3
10	94	9.0
11	106	13.6
12	98	9.6
13	102	11.7
14	101	12.5
15	101	11.1
16	100	10.0
17	100	10.5
18	106	11.9
19	100	11.2
20	88	6.6
21	108	17.2
22	97	9.8
23	104	12.2
24	105	12.9
25	101	11.5
26	104	12.1
27	100	11.0
28	103	11.5
29	101	11.1
30	109	14.8
31	103	11.3
32	100	10.2
33	107	13.5
34	111	14.7
35	94	8.9
36	97	9.5
37	100	11.1

Fish#	Length	Weight
38	90	7.6
39	87	6.9
40	109	14.0
41	100	11.5
42	85	6.2
43	98	10.4
44	102	11.3
45	92	7.6
46	99	9.5
47	101	11.3
48	100	10.5
49	105	13.2
50	95	10.0
51	103	12.7
52	98	9.6
53	105	12.3
54	94	7.9
55	103	10.7
56	99	10.1
57	96	9.7
58	104	11.9
59	93	8.4
60	107	13.5
61	98	9.5
62	103	11.3
63	95	8.5
64	100	10.0
65	101	11.6
66	107	13.7
67	105	12.2
68	113	15.4
69	99	10.0
70	91	8.7
71	98	9.3
72	98	9.5
73	101	10.7
74	94	10.8

Fish#	Length	Weight
75	103	10.8
76	106	12.1
77	95	8.4
78	91	7.4
79	96	8.8
80	98	9.3
81	107	13.5
82	94	9.3
83	108	14.5
84	104	13.2
85	99	11.5
86	96	9.5
87	100	10.8
88	102	11.7

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon for the injection exposure to extract of reference sediment from the Nisqually River Estuary (NQSE).

Treatment: NQSE
Date: 7/9/97

Tank: 11

Fish#	Length	Weight
1	81	5.5
2	89	6.9
3	83	5.6
4	86	6.2
5	87	6.3
6	90	6.6
7	97	8.8
8	94	7.8
9	83	5.6
10	93	8.1
11	90	6.5
12	82	5.6
13	81	4.7
14	89	6.8
15	84	5.7
16	87	6.0
17	90	7.2
18	92	7.3
19	85	5.6
20	88	7.0
21	83	5.2
22	80	4.6
23	85	5.6
24	82	5.6
25	80	4.9
26	94	9.1
27	83	4.9
28	89	7.0
29	80	5.1
30	80	5.1
31	82	5.4
32	90	7.4
33	88	6.9
34	83	5.1
35	90	6.3
36	85	6.1
37	94	8.8
38	96	9.1

Fish#	Length	Weight
39	89	7.0
40	85	5.8
41	86	5.9
42	87	5.6
43	82	5.5
44	80	4.6
45	94	8.1
46	81	5.2
47	81	4.7
48	82	5.3
49	88	7.3
50	95	8.0
51	86	5.7
52	93	7.1
53	84	5.8
54	80	5.3
55	87	6.4
56	89	6.5
57	86	6.4
58	91	6.7
59	81	5.1
60	80	4.9
61	86	5.9
62	89	6.1
63	90	7.2
64	86	6.2
65	84	4.9
66	82	5.1
67	87	6.9
68	88	6.7
69	89	7.2
70	85	6.0
71	82	5.7
72	84	5.3
73	92	7.3
74	86	6.4
75	86	5.6
76	85	5.9

Fish#	Length	Weight
77	92	7.8
78	92	7.3
79	95	7.8
80	82	5.6
81	81	5.7
82	81	5.5
83	80	4.8
84	86	5.6
85	86	6.4
86	90	6.7
87	91	8.1
88	82	4.8
89	81	5.2
90	82	5.3
91	85	5.7
92	80	5.0
93	81	5.3
94	80	5.1
95	85	5.1
96	83	5.5
97	86	5.8
98	88	6.8
99	90	6.6
100	84	5.7
101	89	7.3
102	81	5.0
103	89	7.5
104	89	7.2
105	83	6.0
106	87	5.4
107	80	5.0
108	87	6.1
109	83	5.1
110	89	7.1
111	85	6.1
112	89	7.2
113	83	5.3
114	82	5.5

Fish#	Length	Weight
115	89	7.8
116	91	7.3
117	89	6.8
118	86	6.1
119	92	7.7
120	88	5.9
121	80	4.4
122	89	7.4
123	83	5.5
124	89	6.5
125	82	5.1
126	80	5.0
127	93	8.3
128	81	4.8
129	80	5.5
130	82	4.5
131	82	5.7
132	90	6.6
133	86	6.1
134	81	4.3
135	85	6.3
136	87	6.4
137	90	7.4
138	84	5.7
139	82	4.2
140	82	5.4
141	84	6.2
142	89	6.5
143	86	7.1
144	89	7.1
145	87	5.6
146	80	5.5
147	86	5.5
148	83	5.7
149	82	5.2
150	87	6.1

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon for the injection exposure to extract of reference sediment from the Nisqually River Estuary (NQSE).

Treatment: NQSE
Date: 7/9/97

Tank: 11

Fish#	Length	Weight
151	80	4.9
152	90	7.8
153	96	9.3
154	82	5.3
155	93	7.6
156	80	5.1
157	88	6.0
158	82	4.8
159	84	6.0
160	85	6.1
161	85	5.8
162	87	6.6
163	90	7.1
164	80	5.2
165	84	5.3
166	84	5.8
167	95	8.5
168	89	6.3
169	90	6.7
170	83	5.0
171	84	5.7
172	83	6.2
173	91	8.0
174	84	6.0
175	81	5.3
176	80	5.1
177	88	6.3
178	82	5.2
179	80	5.1
180	93	7.9
181	89	6.3
182	83	5.3
183	85	6.4
184	84	6.0
185	82	5.6
186	82	5.7
187	83	5.7
188	99	9.2

Fish#	Length	Weight
189	81	5.3
190	86	6.0
191	85	5.5
192	80	4.9
193	85	5.6
194	82	5.7
195	86	5.9
196	90	6.2
197	87	6.0
198	83	5.2
199	83	5.4
200	83	4.9
201	87	6.6
202	82	5.1
203	93	7.7
204	84	5.6
205	81	5.6
206	83	5.4
207	84	5.5
208	82	5.4
209	82	5.3
210	82	5.0
211	80	5.2
212	81	5.1
213	88	6.5
214	82	5.7
215	85	5.9
216	89	6.4
217	86	5.7
218	91	7.2
219	84	6.0
220	85	6.8
221	89	7.0
222	83	5.3
223	80	5.4
224	89	7.3
225	80	5.2
226	85	6.0

Fish#	Length	Weight
227	91	7.5
228	88	6.4
229	82	5.0
230	86	6.0
231	82	5.4
232	94	8.4
233	85	5.8
234	86	6.3
235	86	6.0
236	92	7.2
237	89	6.6
238	87	6.1
239	81	5.1
240	93	8.6
241	80	4.9
242	85	6.2
243	83	5.4
244	81	4.7
245	82	4.7
246	85	6.3
247	80	5.0
248	83	5.6
249	90	7.6
250	82	5.5
251	83	5.8
252	85	6.2
253	91	7.3
254	92	7.0
255	85	5.9
256	87	6.4
257	91	7.0
258	87	6.5
259	90	7.0
260	92	7.3
261	81	5.6
262	93	7.8
263	94	8.7
264	96	8.8

Fish#	Length	Weight
265	83	6.1
266	90	7.0
267	87	6.6
268	90	7.1
269	81	5.6
270	85	5.9
271	83	5.8
272	83	5.8
273	84	5.8
274	80	4.6
275	91	7.3
276	89	6.6
277	90	6.7
278	82	5.1
279	80	5.0

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon exposed to NQSE and sampled at 6 d post exposure.

Treatment: NQSE Tank: 11
Date: 7/15/97

Fish#	Length	Weight	Fish#	Length	Weight	Fish#	Length	Weight
1	84	5.6	38	80	5.6	75	91	8.6
2	80	4.9	39	82	5.2			
3	93	8.2	40	84	6.3			
4	84	6.2	41	90	6.6			
5	86	7.4	42	80	5.5			
6	82	4.5	43	87	6.4			
7	87	6.9	44	82	5.7			
8	80	5.2	45	86	7.2			
9	86	6.3	46	94	8.5			
10	85	6.4	47	81	5.5			
11	93	8.4	48	83	6.1			
12	85	5.4	49	85	6.0			
13	90	7.3	50	84	6.2			
14	80	5.4	51	83	5.4			
15	86	6.7	52	80	5.0			
16	94	9.3	53	84	6.1			
17	82	5.4	54	82	5.0			
18	93	8.5	55	83	6.1			
19	89	7.1	56	93	8.3			
20	91	7.5	57	83	5.4			
21	80	5.2	58	83	5.3			
22	80	5.1	59	83	6.0			
23	93	7.9	60	83	5.9			
24	82	5.4	61	83	5.4			
25	86	6.6	62	81	5.6			
26	91	8.2	63	93	8.1			
27	85	5.7	64	82	5.0			
28	83	5.7	65	88	7.8			
29	87	6.9	66	83	5.5			
30	81	6.2	67	89	6.7			
31	87	7.0	68	94	7.8			
32	92	7.8	69	90	7.1			
33	83	4.7	70	90	7.2			
34	90	7.5	71	84	6.2			
35	88	6.9	72	82	5.8			
36	81	5.8	73	94	8.5			
37	82	5.0	74	86	6.3			

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon exposed to NQSE in the Biomarker study and sampled at 20 d post exposure.

Treatment: NQSE Tank: 11
Date: 7/29/97

Fish#	Length	Weight	Fish#	Length	Weight	Fish#	Length	Weight
1	94	8.1	38	88	6.8	75	91	8.2
2	93	8.2	39	89	7.5	76	93	8.3
3	94	9.3	40	89	7.6	77	94	8.6
4	86	7.0	41	84	6.1	78	89	7.1
5	89	8.5	42	86	6.7	79	96	9.1
6	92	8.1	43	90	7.7	80	100	9.4
7	88	8.0	44	92	8.3	81	85	6.5
8	95	9.2	45	92	7.9	82	87	7.1
9	93	8.8	46	99	10.9	83	97	9.9
10	88	7.0	47	94	9.4	84	89	7.8
11	103	12.4	48	94	9.4	85	85	6.6
12	95	8.7	49	88	7.3			
13	89	7.5	50	85	7.0			
14	89	7.8	51	88	7.6			
15	94	8.8	52	96	9.6			
16	96	9.6	53	94	8.7			
17	93	8.2	54	95	8.6			
18	104	11.6	55	92	8.5			
19	91	7.2	56	92	8.5			
20	95	9.6	57	93	8.0			
21	97	7.0	58	95	8.9			
22	91	7.7	59	99	10.5			
23	93	8.9	60	88	7.0			
24	84	6.1	61	87	7.5			
25	88	7.6	62	91	7.7			
26	94	8.3	63	95	8.5			
27	98	9.9	64	93	8.7			
28	89	8.9	65	88	7.5			
29	96	10.1	66	85	6.7			
30	101	10.4	67	93	8.5			
31	100	11.1	68	89	7.7			
32	90	8.6	69	106	13.9			
33	94	8.8	70	87	6.5			
34	102	12.0	71	90	7.5			
35	89	7.0	72	98	9.3			
36	99	9.7	73	90	7.9			
37	90	7.6	74	95	9.1			

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon exposed to NQSE in the Biomarker study and sampled at 33 d post exposure.

NQSE Tank: 11

Date: 8/11/97

Fish#	Length	Weight
1	95	9.4
2	110	17.0
3	100	12.1
4	109	18.6
5	109	15.2
6	100	12.3
7	100	11.7
8	104	12.7
9	101	11.8
10	102	13.6
11	105	14.3
12	104	13.3
13	109	17.3
14	96	9.6
15	110	16.4
16	106	14.7
17	107	14.1
18	94	10.0
19	97	9.3
20	92	9.3
21	96	9.8
22	96	9.7
23	93	8.3
24	108	15.0
25	106	13.2
26	99	11.8
27	105	12.7
28	94	9.0
29	86	5.9
30	111	15.4
31	111	14.6
32	105	14.4
33	93	9.2
34	90	7.3
35	97	10.4
36	83	6.7
37	94	8.7
38	83	5.7
39	96	9.1

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon for the injection exposure to HWSE-M.

Treatment: HWSE-M Tank: 9
Date: 7/9/97

Fish#	Length	Weight
1	91	6.9
2	93	6.2
3	88	7.2
4	85	5.8
5	82	6.9
6	84	5.5
7	83	5.4
8	92	6.9
9	91	7.9
10	82	5.2
11	80	4.9
12	87	6.0
13	87	6.4
14	89	6.6
15	82	5.4
16	81	5.5
17	86	7.1
18	89	6.0
19	89	6.8
20	86	6.6
21	84	5.4
22	92	7.6
23	95	7.4
24	92	7.7
25	80	4.9
26	85	5.6
27	89	6.7
28	89	6.0
29	87	7.1
30	90	7.0
31	85	5.5
32	83	5.3
33	85	6.2
34	87	5.9
35	84	5.7
36	85	5.7
37	81	5.4
38	80	4.7
39	86	6.0
40	83	5.4
41	88	5.5
42	85	6.2
43	88	6.6
44	80	4.4
45	84	5.8
46	87	6.6
47	81	4.7
48	81	5.9
49	85	5.7
50	89	7.0
51	91	6.6
52	88	7.0
53	89	6.8
54	87	5.9
55	82	5.1
56	81	5.1
57	90	7.0
58	86	6.1
59	85	6.1
60	87	6.3
61	89	7.4
62	82	5.6
63	88	6.3
64	91	6.5
65	85	6.1
66	90	6.9
67	82	5.6
68	84	4.9
69	87	5.9
70	89	6.2
71	87	5.8
72	82	5.4
73	80	5.3
74	80	5.4
75	82	5.5
76	88	7.4
77	89	6.8
78	85	6.2
79	84	5.4
80	86	5.5
81	80	4.2
82	85	6.2
83	81	5.0
84	86	6.5
85	87	6.5
86	84	6.1
87	87	6.0
88	83	6.1
89	92	7.3
90	89	7.5
91	80	4.5
92	87	6.4
93	87	6.1
94	88	6.0
95	88	6.2
96	84	5.6
97	82	5.4
98	82	5.2
99	80	4.9
100	91	7.5
101	90	7.0
102	86	6.4
103	89	6.7
104	87	5.8
105	84	6.0
106	81	5.0
107	85	6.1
108	84	5.6
109	87	6.0
110	91	7.5
111	86	5.8
112	87	6.8
113	85	4.9
114	89	6.3
115	86	6.4
116	88	6.4
117	90	6.5
118	81	4.7
119	89	6.8
120	81	4.8
121	80	4.7
122	84	5.9
123	80	4.6
124	85	6.4
125	82	5.2
126	86	5.9
127	82	4.5
128	84	5.8
129	90	6.8
130	94	7.3
131	82	5.6
132	91	7.3
133	95	8.6
134	83	5.3
135	84	5.3
136	83	5.6
137	84	4.9
138	86	6.1
139	85	5.0
140	82	5.0
141	81	5.1
142	91	7.0
143	80	4.7
144	87	6.2
145	94	8.2
146	85	5.2
147	80	5.7
148	89	7.2
149	81	4.9
150	87	6.1

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon for the injection exposure to HWSE-M.

Treatment: HWSE-M
Date: 7/9/97

Tank: 9

Fish#	Length	Weight
151	85	5.9
152	88	5.8
153	91	7.3
154	94	7.7
155	83	5.7
156	87	6.6
157	83	5.2
158	82	5.8
159	98	9.7
160	88	6.7
161	86	5.7
162	89	7.0
163	90	7.0
164	86	6.1
165	89	6.8
166	87	6.1
167	85	5.0
168	89	6.6
169	82	5.5
170	84	5.6
171	80	4.6
172	85	5.7
173	83	5.0
174	82	5.1
175	83	5.0
176	89	6.9
177	83	5.4
178	90	6.8
179	88	6.0
180	84	4.3
181	85	6.2
182	85	6.2
183	87	5.8
184	88	6.5
185	87	5.9
186	85	5.2
187	94	7.7
188	82	5.0

Fish#	Length	Weight
189	88	5.1
190	89	6.1
191	86	6.1
192	82	5.3
193	82	5.6
194	86	5.4
195	80	4.4
196	92	7.1
197	93	7.6
198	81	5.0
199	85	6.4
200	85	5.8
201	98	9.1
202	90	6.7
203	94	8.2
204	92	7.3
205	94	8.0
206	97	8.9
207	93	7.8
208	83	5.2
209	86	6.0
210	90	7.5
211	88	6.3
212	85	5.7
213	81	5.7
214	86	6.0
215	87	6.4
216	91	7.8
217	82	4.7
218	93	7.7
219	92	7.3
220	80	4.7
221	92	7.8
222	87	6.7
223	85	6.0
224	89	6.6
225	89	7.5
226	80	4.8

Fish#	Length	Weight
227	87	6.3
228	85	5.9
229	97	8.1
230	87	7.7
231	83	5.2
232	82	4.6
233	82	5.6
234	86	6.1
235	89	6.8
236	88	6.4
237	92	7.0
238	86	5.8
239	90	6.8
240	89	6.7
241	82	5.4
242	87	6.1
243	89	6.7
244	80	5.4
245	89	7.0
246	80	5.3
247	87	6.7
248	84	5.4
249	85	6.6
250	86	6.4
251	89	6.7
252	84	6.0
253	83	5.7
254	88	6.2
255	82	5.2
256	80	5.6
257	89	6.7
258	86	6.6
259	97	9.7
260	93	7.5
261	83	5.3
262	89	6.6
263	86	5.2
264	85	6.0

Fish#	Length	Weight
265	82	5.0
266	87	6.3
267	90	6.5
268	90	8.0
269	87	6.3
270	85	6.0
271	80	4.6
272	88	5.8
273	81	5.0
274	84	5.1
275	86	6.2
276	86	6.3
277	89	6.5
278	84	5.1
279	86	6.2
280	86	6.2
281	94	8.0
282	88	5.3
283	92	7.8
284	87	6.2
285	83	5.6
286	84	5.5
287	91	7.2
288	90	6.9
289	97	9.0
290	91	7.1
291	84	4.8
292	90	7.4
293	83	5.7
294	97	9.0
295	80	5.1
296	84	5.3
297	93	7.5
298	85	6.2
299	92	7.1
300	89	6.1

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon, exposed to HWSE-M in the Biomarker study, sampled at 6 d post exposure.

Treatment: HWSE-M Tank: 9
Date: 7/15/97

Fish#	Length	Weight	Fish#	Length	Weight	Fish#	Length	Weight
1	80	5.1	38	90	7.4	75	90	7.9
2	84	5.0	39	88	7.1			
3	87	7.1	40	94	8.6			
4	80	5.5	41	87	7.3			
5	88	7.4	42	80	4.9			
6	86	6.9	43	88	7.0			
7	84	6.0	44	90	7.9			
8	85	6.0	45	86	6.2			
9	80	5.7	46	97	8.0			
10	94	8.8	47	92	8.2			
11	90	7.2	48	94	8.5			
12	90	7.9	49	90	8.2			
13	87	6.9	50	86	5.9			
14	80	5.5	51	95	8.7			
15	80	6.5	52	82	5.9			
16	80	5.8	53	82	6.2			
17	80	5.5	54	90	7.1			
18	82	6.4	55	94	8.4			
19	80	5.6	56	85	6.0			
20	88	7.7	57	81	5.2			
21	92	7.9	58	84	6.3			
22	85	5.7	59	85	6.4			
23	90	7.8	60	85	6.5			
24	84	6.5	61	90	7.7			
25	92	8.1	62	81	4.9			
26	85	5.7	63	87	6.8			
27	91	7.7	64	86	6.8			
28	84	5.4	65	96	9.9			
29	88	6.6	66	82	5.9			
30	85	6.2	67	86	6.9			
31	89	6.4	68	81	5.1			
32	80	5.4	69	81	5.3			
33	85	6.5	70	84	5.6			
34	80	5.6	71	80	4.4			
35	80	5.4	72	85	5.9			
36	87	6.0	73	88	7.0			
37	80	5.6	74	89	6.8			

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon, exposed to HWSE-M in the Biomarker study, sampled at 20 d post exposure.

Treatment: HWSE-M Tank: 9

Date: 7/29/97

Fish#	Length	Weight	Fish#	Length	Weight	Fish#	Length	Weight
1	91	7.6	38	89	7.3	75	88	7.2
2	88	7.1	39	82	5.2	76	90	7.6
3	84	5.8	40	93	8.4	77	79	4.0
4	85	6.3	41	89	7.9	78	92	8.7
5	92	8.7	42	92	8.8	79	105	12.5
6	90	7.3	43	88	6.9	80	84	5.5
7	96	10.2	44	86	6.6	81	94	8.5
8	87	6.9	45	91	8.6	82	87	6.7
9	97	9.7	46	98	9.9	83	88	6.9
10	83	5.9	47	85	6.7	84	80	4.7
11	95	8.5	48	93	8.3	85	87	6.7
12	90	7.9	49	86	6.6			
13	94	9.0	50	99	10.2			
14	98	10.9	51	94	9.2			
15	93	8.5	52	94	9.1			
16	85	6.7	53	98	11.1			
17	94	9.1	54	82	5.9			
18	91	8.3	55	96	9.9			
19	102	10.4	56	86	6.8			
20	92	8.7	57	96	9.5			
21	87	7.3	58	84	5.5			
22	86	7.3	59	91	7.8			
23	92	8.4	60	91	8.5			
24	87	6.9	61	96	10.1			
25	86	6.8	62	92	8.5			
26	85	6.2	63	96	10.2			
27	84	6.4	64	95	9.0			
28	85	7.0	65	81	5.6			
29	91	7.6	66	89	7.4			
30	93	9.8	67	93	8.4			
31	93	8.8	68	87	7.3			
32	95	8.8	69	94	8.2			
33	86	6.9	70	88	7.8			
34	96	9.8	71	89	7.5			
35	97	9.2	72	92	9.3			
36	89	8.4	73	82	5.7			
37	95	9.8	74	82	5.2			

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposd to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon, exposed to HWSE-M in the Biomarker study, sampled at 33 d post exposure.

Treatment: HWSE-M Tank: 9
Date: 8/11/97

Fish#	Length	Weight
1	98	10.5
2	115	19.0
3	94	10.1
4	94	9.3
5	103	12.5
6	95	9.7
7	108	14.0
8	93	9.0
9	98	11.4
10	99	10.1
11	99	10.4
12	95	10.4
13	101	10.8
14	109	16.5
15	93	8.9
16	118	19.9
17	105	13.0
18	102	12.5
19	98	11.4
20	105	12.5
21	100	11.3
22	90	8.7
23	94	8.2
24	91	7.5
25	88	7.0
26	107	13.9
27	94	8.8
28	99	9.9
29	97	10.6
30	97	9.2
31	96	8.8
32	90	10.3
33	98	10.1
34	102	13.3
35	100	9.8
36	95	9.5
37	96	10.1

Fish#	Length	Weight
38	98	11.3
39	85	6.7

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon for the injection exposure to HWSE-P.

Treatment: HWSE-P Tank: 4
Date: 7/9/97

Fish#	Length	Weight
1	88	6.7
2	98	8.8
3	87	7.1
4	83	5.7
5	87	6.9
6	83	4.5
7	88	6.0
8	85	5.9
9	83	5.8
10	80	4.8
11	85	5.4
12	83	5.2
13	86	5.5
14	88	6.0
15	80	4.9
16	83	5.2
17	86	5.9
18	92	7.3
19	85	6.0
20	83	5.9
21	85	5.7
22	91	6.5
23	90	7.0
24	87	6.5
25	88	6.6
26	82	4.8
27	88	6.2
28	81	5.2
29	82	5.0
30	89	6.6
31	84	5.7
32	97	9.3
33	82	5.2
34	95	8.2
35	83	5.9
36	95	8.0
37	87	6.1
38	81	4.9
39	92	7.5
40	86	5.8
41	89	6.9
42	87	5.9
43	95	8.2
44	94	7.4
45	82	5.0
46	87	6.4
47	87	6.5
48	81	5.3
49	87	6.0
50	80	4.5
51	86	5.7
52	86	5.5
53	96	7.7
54	82	5.1
55	81	5.0
56	82	4.9
57	81	4.8
58	84	6.0
59	89	6.0
60	80	5.0
61	81	5.0
62	80	5.4
63	83	6.3
64	86	5.8
65	94	8.1
66	85	5.3
67	82	5.5
68	88	6.7
69	89	7.1
70	88	6.4
71	98	9.5
72	91	7.0
73	89	7.0
74	82	5.3
75	83	6.0
76	85	6.4
77	80	4.3
78	84	6.1
79	84	5.9
80	82	4.8
81	81	5.0
82	89	6.6
83	90	7.1
84	90	6.7
85	85	6.2
86	85	5.7
87	100	10.4
88	85	5.9
89	85	5.6
90	87	6.6
91	80	5.0
92	82	5.1
93	87	7.1
94	84	5.5
95	81	4.8
96	86	6.4
97	81	4.9
98	88	7.1
99	82	5.2
100	84	4.9
101	85	6.5
102	85	5.4
103	85	6.3
104	81	5.2
105	84	5.3
106	80	4.8
107	81	4.8
108	86	5.9
109	88	6.5
110	85	5.9
111	83	5.0
112	94	8.5
113	85	5.5
114	88	6.8
115	84	5.8
116	81	5.5
117	80	4.9
118	83	5.6
119	83	5.4
120	82	5.5
121	83	5.3
122	81	4.9
123	85	5.3
124	93	8.7
125	89	6.6
126	86	5.6
127	83	5.2
128	84	5.6
129	85	6.6
130	84	4.7
131	85	6.1
132	85	6.2
133	84	5.0
134	87	6.1
135	90	7.7
136	83	5.3
137	83	5.8
138	88	6.3
139	90	7.2
140	84	5.9
141	84	6.0
142	87	6.0
143	86	5.9
144	85	6.8
145	94	8.4
146	83	5.8
147	82	5.2
148	80	4.7
149	89	6.5
150	89	7.1
151	85	5.9
152	93	8.4
153	89	7.1
154	82	5.9
155	84	6.0
156	80	5.6
157	86	6.7
158	82	5.2
159	87	6.2
160	88	6.7
161	83	5.7
162	87	6.7
163	82	5.1
164	80	5.4
165	87	6.4
166	85	5.9
167	81	4.8
168	89	7.7
169	82	5.7
170	80	5.1
171	82	5.6
172	81	4.7
173	84	5.9
174	82	5.0
175	86	6.2
176	81	5.2
177	80	4.5
178	82	5.5
179	84	5.0
180	91	6.3
181	84	4.3
182	82	5.0

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon, exposed to HWSE-P in the Biomarker study, sampled at 6 d post exposure.

Treatment: HWSE-P Tank:
Date: 7/15/97

Fish#	Length	Weight
1	83	5.9
2	85	5.7
3	85	6.7
4	85	6.2
5	84	5.7
6	85	7.3
7	93	9.0
8	99	10.9
9	82	7.1
10	82	5.7
11	84	6.4
12	88	7.5
13	102	12.4
14	81	5.9
15	85	6.4
16	90	8.8
17	81	5.7
18	97	10.0
19	88	8.1
20	88	7.0
21	85	6.4
22	96	10.3
23	88	8.1
24	83	6.2
25	87	7.7
26	84	7.3
27	86	7.5
28	83	6.0
29	82	5.6
30	84	6.5
31	ND	ND
32	83	5.3
33	85	6.6
34	81	5.9
35	84	6.0
36	80	5.1
37	90	8.0
38	84	6.2
39	93	8.6
40	88	7.3
41	85	7.4
42	82	6.0
43	84	6.1
44	82	5.8
45	92	7.9

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon, exposed to HWSE-P in the Biomarker study, sampled at 20 d post exposure.

Treatment: HWSE-P Tank: 4
Date: 7/29/97

Fish#	Length	Weight
1	90	7.5
2	96	10.0
3	98	10.3
4	84	6.2
5	93	8.5
6	88	7.5
7	94	8.0
8	97	10.5
9	85	6.4
10	97	10.3
11	87	7.5
12	88	7.4
13	89	7.6
14	87	7.1
15	100	11.7
16	93	9.1
17	93	8.6
18	95	10.3
19	96	9.4
20	85	6.6
21	103	11.7
22	85	6.2
23	95	9.1
24	95	9.5
25	92	8.0
26	87	6.7
27	90	7.8
28	90	8.8
29	92	8.3
30	91	8.6
31	90	6.6
32	97	10.6
33	98	9.9
34	98	9.8
35	94	10.1
36	94	9.6
37	90	8.2

Fish#	Length	Weight
38	91	8.2
39	93	8.3
40	86	7.0
41	92	8.8
42	93	7.9
43	97	10.0
44	81	5.2
45	91	7.9
46	101	12.0
47	88	7.8
48	97	9.9
49	92	8.2
50	88	7.2
51	89	10.8
52	98	11.0
53	100	12.5
54	87	7.5
55	91	8.2

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposd to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon, exposed to HWSE-P in the Biomarker study, sampled at 56 d post exposure.

Treatment: HWSE-P Tank: 4
Date: 9/3/97

Fish#	Length	Weight
1	112	18.5
2	132	29.0
3	101	13.2
4	117	19.0
5	113	16.2
6	99	11.0
7	90	7.4
8	93	9.2
9	98	10.2
10	104	12.9
11	99	10.4
12	110	15.8
13	97	9.5
14	98	9.3
15	102	13.2
16	99	11.9
17	108	15.2
18	136	28.7
19	106	18.7
20	105	19.0
21	110	16.2
22	97	10.5
23	122	24.2
24	106	14.3
25	94	9.1
26	128	25.4
27	109	11.3
28	110	14.9
29	115	18.3
30	105	13.4
31	103	12.2
32	110	11.9
33	103	11.7
34	108	14.3

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon for the injection exposure to HCBD.

Treatment: HCBD Tank: 8
Date: 7/9/97

Fish#	Length	Weight	Fish#	Length	Weight	Fish#	Length	Weight	Fish#	Length	Weight
1	89	7.4	39	93	7.6	77	81	4.8	115	88	6.9
2	83	4.8	40	84	5.7	78	83	4.9	116	86	5.6
3	90	7.5	41	95	8.2	79	84	6.0	117	91	7.1
4	96	7.5	42	94	8.8	80	88	6.4	118	98	8.5
5	96	8.4	43	86	6.5	81	95	8.1	119	90	7.1
6	98	9.0	44	88	6.8	82	93	7.0	120	85	5.7
7	87	6.2	45	81	4.9	83	85	6.0	121	80	5.6
8	85	5.4	46	86	5.6	84	91	7.1	122	92	7.2
9	93	7.7	47	86	5.7	85	82	4.8	123	81	5.0
10	84	5.8	48	91	7.4	86	88	5.8	124	88	6.5
11	88	6.1	49	89	6.2	87	87	5.2	125	92	7.4
12	88	6.6	50	91	7.3	88	84	5.9	126	85	5.7
13	89	5.6	51	89	6.7	89	93	8.0	127	84	5.3
14	84	5.6	52	86	5.8	90	85	5.7	128	93	7.7
15	94	7.5	53	86	6.5	91	85	5.9	129	80	5.4
16	87	6.4	54	84	5.5	92	95	7.9	130	86	6.3
17	91	7.1	55	92	7.1	93	86	5.8	131	91	6.9
18	81	5.0	56	93	8.1	94	82	5.1	132	82	5.2
19	85	5.8	57	88	6.3	95	92	7.5	133	98	8.5
20	87	7.0	58	85	5.4	96	88	6.5	134	94	8.3
21	83	5.3	59	91	7.9	97	84	5.6	135	85	5.6
22	89	6.1	60	84	5.7	98	87	5.8	136	87	6.3
23	89	6.9	61	86	6.2	99	86	5.9	137	89	7.0
24	89	6.9	62	89	6.1	100	90	7.3	138	89	6.6
25	84	5.3	63	80	5.3	101	91	7.2	139	93	8.0
26	89	6.3	64	85	5.6	102	82	5.5	140	95	7.6
27	91	6.8	65	89	6.9	103	83	6.1	141	89	7.1
28	83	5.3	66	85	5.9	104	86	6.4	142	94	8.5
29	86	6.4	67	90	6.9	105	82	5.6	143	88	5.9
30	88	6.5	68	85	5.9	106	88	6.8	144	88	6.2
31	90	7.0	69	83	5.4	107	89	6.6	145	86	6.3
32	83	5.7	70	89	6.7	108	83	6.0	146	89	6.4
33	90	6.3	71	83	5.0	109	90	7.0	147	86	5.3
34	95	8.2	72	96	9.4	110	87	6.3	148	94	7.5
35	91	6.8	73	89	6.5	111	81	4.9	149	90	7.2
36	88	6.4	74	97	8.9	112	81	5.1	150	87	5.9
37	88	6.3	75	87	6.0	113	91	7.1			
38	92	7.7	76	82	4.6	114	87	6.4			

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon for the injection exposure to HCBD.

Treatment: HCBD
Date: 7/9/97

Tank: 8

Fish#	Length	Weight
151	83	5.3
152	93	7.6
153	80	4.5
154	84	5.5
155	94	8.3
156	88	5.9
157	88	6.8
158	91	7.1
159	88	6.4
160	82	4.9
161	81	5.3
162	89	6.3
163	82	5.1
164	96	8.9
165	81	4.9
166	89	6.4
167	83	5.1
168	86	6.3
169	80	4.8
170	84	6.1
171	84	5.8
172	89	6.6
173	95	8.3
174	85	6.1
175	80	5.0
176	81	4.7
177	97	9.0
178	87	6.8
179	89	7.2
180	87	6.8
181	92	8.0
182	91	7.3
183	85	5.1
184	87	6.2
185	96	8.0
186	86	5.6
187	90	6.8
188	87	6.0
189	88	6.4
190	86	5.8
191	88	7.2
192	80	4.8
193	85	5.6
194	96	8.1
195	84	5.8
196	93	7.8
197	89	7.1
198	86	5.8
199	89	6.7
200	91	7.3
201	84	5.7
202	91	7.1
203	80	4.9
204	90	7.0
205	83	5.0
206	82	5.2
207	88	5.9
208	87	6.2
209	91	7.5
210	86	6.0
211	89	6.8
212	87	6.5
213	92	7.1
214	84	6.3
215	94	7.6
216	82	5.6
217	86	6.0
218	86	6.9
219	80	4.7
220	83	4.8
221	86	6.0
222	93	8.3
223	83	5.3
224	91	7.7
225	86	6.1
226	86	5.8
227	91	7.7
228	80	4.9
229	83	5.2
230	98	9.5
231	86	6.5
232	87	7.0
233	88	6.7
234	94	8.2
235	80	4.9
236	89	6.6
237	82	4.9
238	93	7.9
239	83	6.9
240	88	7.0
241	87	6.7
242	89	6.5
243	81	5.6
244	86	6.1
245	92	7.5
246	89	6.6
247	87	7.4
248	86	5.1
249	84	5.5
250	94	8.0
251	83	6.0
252	86	6.3
253	95	7.7
254	87	6.4
255	82	5.7
256	86	6.2
257	86	5.6
258	83	6.0
259	90	7.1
260	85	5.6
261	84	5.3
262	82	5.9
263	84	5.8
264	85	5.6
265	88	6.0
266	86	6.0
267	84	5.0
268	90	6.9
269	87	6.4
270	93	7.6
271	82	5.8
272	83	5.4
273	82	5.2
274	81	4.5
275	92	7.4
276	81	4.9
277	84	6.4
278	84	5.5
279	81	4.9
280	86	5.5
281	89	6.6
282	84	5.7
283	89	6.7
284	86	6.3
285	93	7.7
286	88	6.3
287	85	5.8
288	90	8.1
289	90	7.6
290	84	5.3
291	81	5.3
292	88	6.6
293	86	6.3
294	87	6.1
295	90	7.1
296	83	5.2
297	83	4.8
298	85	6.1
299	89	6.5
300	85	6.0

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon, exposed to HCBD in the Biomarker study, sampled at 6 d post exposure.

Treatment: HCBD Tank: 8
Date: 7/15/97

Fish#	Length	Weight	Fish#	Length	Weight	Fish#	Length	Weight
1	89	7.1	38	95	8.3	75	85	5.8
2	90	7.5	39	88	6.6			
3	86	6.7	40	85	6.4			
4	83	7.6	41	90	6.1			
5	91	7.6	42	85	6.1			
6	84	5.9	43	82	5.6			
7	89	6.6	44	90	7.5			
8	84	5.6	45	81	5.0			
9	92	8.2	46	92	7.1			
10	86	6.1	47	90	6.6			
11	89	6.5	48	93	7.8			
12	92	7.5	49	86	6.0			
13	95	8.6	50	85	6.3			
14	94	8.1	51	91	7.8			
15	98	9.9	52	93	7.5			
16	82	5.4	53	92	7.4			
17	90	7.5	54	91	6.6			
18	85	6.0	55	85	6.0			
19	87	6.2	56	88	7.1			
20	85	6.0	57	88	6.7			
21	86	6.3	58	84	5.6			
22	83	5.8	59	91	7.8			
23	83	6.0	60	79	4.7			
24	95	7.9	61	85	6.4			
25	83	8.2	62	87	6.5			
26	85	5.9	63	88	6.1			
27	81	5.2	64	88	6.7			
28	83	5.1	65	95	8.7			
29	86	6.4	66	86	6.0			
30	84	5.6	67	87	9.4			
31	91	8.0	68	89	6.7			
32	90	8.0	69	87	6.0			
33	86	6.5	70	90	7.3			
34	80	5.4	71	93	7.6			
35	91	7.4	72	93	6.7			
36	86	6.0	73	94	7.3			
37	85	5.6	74	90	6.9			

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon, exposed to HCBD in the Biomarker study, sampled at 20 d post exposure.

Treatment: HCBD Tank: 8
Date: 7/29/97

Fish#	Length	Weight	Fish#	Length	Weight	Fish#	Length	Weight
1	85	6.2	38	83	6.0	75	90	7.4
2	87	8.4	39	102	11.7	76	87	7.3
3	95	9.4	40	88	7.7	77	86	6.5
4	86	5.6	41	93	8.7	78	84	6.4
5	101	11.1	42	93	8.7	79	98	10.2
6	100	11.1	43	87	6.8	80	88	7.5
7	85	7.1	44	93	8.3	81	96	9.5
8	87	6.8	45	87	7.6	82	90	7.5
9	98	10.6	46	92	8.9	83	83	5.8
10	95	9.2	47	89	7.9	84	91	8.4
11	88	7.8	48	92	9.5	85	94	8.4
12	88	6.8	49	94	8.9			
13	94	9.5	50	87	7.2			
14	94	8.9	51	87	6.9			
15	93	8.8	52	84	6.3			
16	89	7.7	53	96	9.9			
17	95	8.7	54	96	9.8			
18	91	8.5	55	93	8.8			
19	89	8.1	56	86	6.5			
20	87	6.8	57	85	6.6			
21	93	8.9	58	97	10.5			
22	94	9.2	59	92	8.7			
23	91	8.1	60	97	9.7			
24	92	8.4	61	92	9.1			
25	91	8.1	62	80	5.1			
26	90	7.2	63	97	9.9			
27	88	7.7	64	88	6.8			
28	97	10.4	65	87	7.0			
29	88	7.2	66	89	7.6			
30	88	8.1	67	85	6.3			
31	94	9.2	68	91	8.7			
32	97	10.0	69	87	7.0			
33	94	9.0	70	93	8.8			
34	89	7.3	71	92	7.5			
35	88	6.8	72	98	10.7			
36	91	8.3	73	97	10.6			
37	92	8.9	74	90	7.6			

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposd to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon, exposed to HCBD in the Biomarker study, sampled at 56 d post exposure.

Treatment: HCBD Tank: 8
Date: 9/3/97

Fish#	Length	Weight	Fish#	Length	Weight	Fish#	Length	Weight
1	120	15.4	38	110	15.0	75	124	22.1
2	103	17.8	39	104	12.9	76	98	11.0
3	100	11.7	40	112	16.5	77	97	9.8
4	110	17.1	41	93	9.2	78	111	16.0
5	111	12.0	42	92	8.9	79	106	14.0
6	114	16.3	43	93	8.8	80	130	27.5
7	115	18.6	44	122	24.6	81	112	16.4
8	105	12.1	45	108	15.0	82	99	10.3
9	104	12.8	46	106	13.0			
10	98	11.3	47	110	16.3			
11	112	16.2	48	110	14.2			
12	91	8.4	49	122	20.4			
13	108	15.5	50	110	15.6			
14	115	17.2	51	108	12.4			
15	117	18.5	52	107	12.9			
16	99	11.1	53	110	13.6			
17	118	18.6	54	97	10.3			
18	94	9.7	55	90	7.7			
19	108	14.8	56	108	14.6			
20	98	10.5	57	105	13.6			
21	97	10.3	58	115	19.1			
22	115	18.9	59	88	7.5			
23	107	13.7	60	104	12.6			
24	104	17.6	61	97	10.0			
25	103	14.7	62	103	11.7			
26	103	12.5	63	107	14.4			
27	124	24.5	64	102	11.5			
28	121	21.6	65	110	15.6			
29	111	17.2	66	118	19.0			
30	115	17.7	67	101	12.7			
31	100	10.3	68	119	20.8			
32	118	22.7	69	100	10.3			
33	110	17.3	70	89	8.1			
34	109	16.8	71	110	16.0			
35	110	16.6	72	108	13.5			
36	113	16.9	73	110	12.2			
37	95	9.8	74	108	14.3			

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon for the injection exposure to PCBs.

Treatment: PCBs Tank: 12
Date: 7/9/97

Fish#	Length	Weight	Fish#	Length	Weight	Fish#	Length	Weight	Fish#	Length	Weight
1	87	6.3	39	85	5.5	77	88	7.2	115	87	5.4
2	86	6.4	40	80	5.2	78	80	4.6	116	83	5.2
3	89	6.2	41	83	5.6	79	91	6.8	117	92	7.6
4	86	6.0	42	83	5.4	80	87	6.4	118	93	7.5
5	84	5.9	43	86	5.5	81	81	5.3	119	82	4.7
6	81	5.7	44	89	6.4	82	80	5.2	120	83	4.8
7	85	5.9	45	88	6.2	83	80	5.0	121	85	6.0
8	80	5.1	46	87	6.2	84	86	6.4	122	85	4.9
9	83	5.5	47	83	5.4	85	85	6.0	123	81	4.7
10	91	7.4	48	88	5.9	86	88	6.2	124	85	5.6
11	82	5.3	49	86	6.4	87	81	5.0	125	86	5.8
12	89	6.1	50	86	5.5	88	92	7.7	126	86	6.4
13	84	5.9	51	85	6.1	89	85	5.6	127	82	5.2
14	83	5.5	52	88	6.6	90	82	4.8	128	87	6.5
15	82	5.1	53	86	5.2	91	88	6.5	129	82	5.4
16	88	6.0	54	83	5.7	92	83	5.8	130	83	4.7
17	91	6.6	55	85	5.4	93	89	6.3	131	85	6.0
18	84	5.6	56	86	5.9	94	83	5.0	132	80	4.6
19	90	6.2	57	80	4.8	95	83	5.5	133	84	5.6
20	80	4.9	58	85	5.6	96	83	5.5	134	81	4.8
21	85	5.8	59	82	4.3	97	87	6.3	135	80	4.5
22	83	5.5	60	80	5.4	98	83	5.5	136	83	5.4
23	80	4.8	61	90	6.7	99	87	6.6	137	85	6.1
24	91	7.6	62	90	7.0	100	89	6.7	138	81	4.9
25	90	5.0	63	85	5.7	101	86	6.1	139	81	5.0
26	91	7.0	64	85	5.4	102	88	6.4	140	85	5.1
27	81	5.1	65	82	5.3	103	90	6.9	141	83	5.0
28	89	6.1	66	84	5.7	104	89	7.1	142	85	6.0
29	90	6.1	67	86	5.6	105	87	6.4	143	83	5.0
30	86	6.6	68	80	4.9	106	82	5.2	144	89	6.2
31	85	6.0	69	80	4.9	107	90	6.8	145	90	6.4
32	89	6.8	70	86	5.6	108	80	5.0	146	83	5.3
33	80	4.7	71	80	4.9	109	86	5.9	147	85	5.4
34	86	6.5	72	90	6.3	110	91	6.7	148	84	5.1
35	82	5.3	73	83	5.2	111	89	6.6	149	80	4.7
36	82	5.8	74	94	8.0	112	86	5.8	150	88	6.8
37	86	6.7	75	85	5.5	113	89	6.0			
38	82	5.4	76	90	6.2	114	92	7.7			

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon for the injection exposure to PCBs.

Treatment: PCBs Tank: 12
Date: 7/9/97

Fish#	Length	Weight
151	83	5.6
152	83	5.4
153	95	8.8
154	86	6.0
155	90	6.8
156	85	5.4
157	87	5.9
158	85	5.8
159	88	6.4
160	86	5.8
161	92	6.9
162	82	4.8
163	85	5.7
164	85	5.9
165	89	6.6
166	84	5.5
167	91	6.6
168	90	7.1
169	82	5.6
170	84	5.0
171	90	7.0
172	86	5.9
173	91	7.1
174	83	5.5
175	81	4.6
176	82	4.4
177	93	7.7
178	92	7.0
179	80	4.8
180	81	4.7
181	80	5.1
182	87	6.0
183	83	5.8
184	85	6.4
185	82	5.6
186	85	5.5
187	87	5.9
188	83	5.8

Fish#	Length	Weight
189	83	5.7
190	83	5.5
191	85	5.4
192	80	4.7
193	84	5.5
194	83	5.3
195	87	6.6
196	88	6.9
197	90	7.1
198	84	4.9
199	80	5.1
200	82	4.3
201	80	4.7
202	81	4.7
203	86	5.8
204	89	6.7
205	82	5.0
206	80	4.9
207	91	7.3
208	85	5.7
209	89	6.2
210	81	5.0
211	89	6.5
212	87	6.3
213	88	6.5
214	81	4.7
215	87	6.3
216	86	5.0
217	80	4.7
218	87	6.0
219	90	6.4
220	85	6.8
221	90	7.4
222	83	5.1
223	87	6.5
224	95	8.4
225	84	6.0
226	89	6.3

Fish#	Length	Weight
227	85	6.0
228	91	6.8
229	89	6.5
230	84	5.3
231	83	5.2
232	85	5.8
233	90	7.3
234	81	4.5
235	88	6.8
236	86	5.9
237	90	7.7
238	90	7.0
239	84	5.6
240	86	5.6
241	84	5.8
242	86	5.5
243	80	4.9
244	96	8.2
245	84	5.4
246	88	6.6
247	81	5.0
248	86	5.9
249	87	6.5
250	81	4.6
251	86	6.0
252	88	6.6
253	80	4.8
254	91	7.4
255	90	6.7
256	86	6.0
257	91	6.5
258	82	5.1
259	85	6.1
260	90	7.0
261	82	5.3
262	83	5.3
263	87	5.9
264	83	5.5

Fish#	Length	Weight
265	80	4.9
266	86	5.7
267	89	6.5
268	83	5.5
269	84	5.4
270	88	6.2
271	98	9.1
272	88	6.6
273	80	4.4
274	93	7.8
275	88	7.0
276	88	6.2
277	87	6.0
278	80	5.0
279	87	6.3
280	84	5.5
281	88	6.6
282	91	7.3
283	82	4.9
284	87	6.0
285	89	6.3
286	90	7.3
287	87	6.5
288	85	5.5
289	94	8.5
290	86	5.6
291	90	6.0
292	94	8.1
293	96	9.0
294	95	7.1
295	90	7.3
296	92	7.3
297	84	6.1
298	88	5.9
299	95	7.9
300	91	7.8

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon, exposed to PCBs in the Biomarker study, sampled at 6 d post exposure.

Treatment: PCBs Tank: 12
Date: 7/15/97

Fish#	Length	Weight	Fish#	Length	Weight	Fish#	Length	Weight
1	85	6.8	38	89	7.3	75	84	6.5
2	96	9.5	39	91	7.7			
3	89	7.8	40	90	7.6			
4	88	6.8	41	85	5.4			
5	89	7.3	42	80	5.0			
6	87	6.7	43	91	8.3			
7	ND	ND	44	91	8.7			
8	87	6.5	45	89	7.2			
9	88	7.1	46	80	5.7			
10	83	6.1	47	92	8.6			
11	85	6.7	48	93	8.7			
12	88	7.0	49	86	6.2			
13	85	6.7	50	80	5.2			
14	89	6.6	51	87	7.9			
15	90	6.7	52	82	5.5			
16	81	5.4	53	95	9.1			
17	82	5.2	54	90	7.3			
18	85	6.8	55	81	5.5			
19	90	7.2	56	80	5.5			
20	90	7.6	57	80	5.4			
21	80	5.5	58	88	6.7			
22	89	6.8	59	87	7.0			
23	90	8.0	60	89	7.1			
24	89	6.7	61	85	6.3			
25	85	7.3	62	86	6.8			
26	84	6.6	63	81	5.5			
27	87	7.3	64	91	7.3			
28	89	7.6	65	89	6.9			
29	80	6.4	66	87	7.0			
30	86	7.3	67	91	7.8			
31	84	5.9	68	80	5.4			
32	90	7.6	69	84	5.9			
33	81	5.7	70	86	7.0			
34	90	5.7	71	80	5.2			
35	97	8.1	72	82	4.7			
36	84	6.4	73	84	6.0			
37	82	6.2	74	80	4.4			

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon, exposed to PCBs in the Biomarker study, sampled at 20 d post exposure.

Treatment: PCBs Tank: 12
Date: 7/29/97

Fish#	Length	Weight
1	95	9.6
2	92	7.8
3	100	11.3
4	85	5.8
5	87	7.5
6	90	8.4
7	95	9.3
8	90	7.6
9	95	9.5
10	85	6.9
11	91	8.5
12	85	6.8
13	95	8.7
14	90	8.1
15	94	9.0
16	84	6.5
17	96	9.6
18	89	8.1
19	86	6.2
20	88	8.3
21	93	8.9
22	93	9.6
23	90	8.2
24	94	9.6
25	89	7.4
26	90	8.6
27	89	7.7
28	84	5.9
29	92	8.6
30	85	6.7
31	87	7.7
32	93	7.8
33	84	5.8
34	88	7.9
35	82	6.3
36	85	5.7
37	90	8.1
38	89	8.0
39	92	8.5
40	93	9.6
41	90	8.1
42	97	9.4
43	90	8.2
44	97	9.5
45	95	9.7
46	91	8.0
47	88	7.5
48	90	8.1
49	90	8.0
50	87	6.7
51	85	6.4
52	82	5.5
53	83	5.4
54	88	7.8
55	93	7.9
56	85	6.8
57	95	9.1
58	91	8.1
59	88	7.6
60	83	6.0
61	88	8.2
62	85	6.5
63	92	8.2
64	93	8.7
65	98	11.2
66	89	8.1
67	86	6.7
68	88	7.2
69	88	7.3
70	87	7.0
71	99	10.7
72	103	12.1
73	93	7.8
74	94	8.9
75	100	11.7
76	87	7.3
77	88	7.1
78	96	9.7
79	91	7.8
80	83	6.4
81	89	7.5
82	95	9.5
83	90	7.9
84	94	8.8
85	93	9.3

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposd to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon, exposed to PCBs in the Biomarker study, sampled at 60 d post exposure.

Treatment: PCBs Tank: 12
Date: 9/9/97

Fish#	Length	Weight
1	98	12.2
2	101	12.0
3	115	17.1
4	118	19.9
5	118	20.4
6	112	17.8
7	110	16.4
8	100	12.3
9	111	16.8
10	116	19.6
11	131	31.4
12	120	20.5
13	122	22.2
14	111	16.3
15	102	12.5
16	113	18.6
17	95	10.1
18	105	14.1
19	118	19.4
20	113	18.4
21	92	8.8
22	111	16.5
23	97	10.4
24	105	15.2
25	96	11.1
26	116	21.1
27	107	13.9
28	106	12.8
29	103	13.2
30	108	15.1
31	115	16.6
32	114	18.3
33	87	7.3
34	103	13.1
35	90	8.4
36	103	12.3
37	111	12.8

Fish#	Length	Weight
38	116	18.3
39	103	13.4
40	101	12.2
41	102	12.1
42	128	24.8
43	117	17.8
44	140	32.0
45	100	11.2
46	111	17.2
47	114	18.6
48	122	25.0
49	122	20.2
50	118	18.1
51	122	23.9
52	96	10.2
53	98	11.6
54	128	26.9
55	109	15.0

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon for the injection exposure to PAHs.

Treatment: PAHs
Date: 7/9/97

Tank: 7

Fish#	Length	Weight
1	86	6.3
2	93	8.4
3	95	8.1
4	91	8.0
5	86	7.3
6	87	6.9
7	90	7.1
8	84	6.0
9	88	6.8
10	88	6.7
11	86	6.5
12	86	5.8
13	87	6.2
14	87	6.4
15	86	6.1
16	88	6.5
17	82	5.2
18	85	5.9
19	81	5.2
20	84	5.8
21	84	6.0
22	81	5.0
23	89	6.8
24	82	5.5
25	85	6.2
26	88	6.0
27	86	5.5
28	82	5.5
29	82	4.8
30	83	5.5
31	90	7.9
32	92	8.2
33	80	5.2
34	81	5.2
35	95	8.6
36	88	7.0
37	94	7.8
38	88	6.5
39	88	6.6
40	95	8.7
41	87	6.8
42	88	6.5
43	89	6.9
44	80	5.1
45	80	4.3
46	90	7.2
47	81	5.9
48	86	6.0
49	92	7.9
50	89	7.1
51	90	6.7
52	85	5.5
53	80	4.5
54	80	4.7
55	90	9.2
56	93	7.6
57	83	4.7
58	84	5.9
59	86	6.1
60	85	7.4
61	84	5.8
62	87	6.6
63	82	5.0
64	81	6.1
65	86	6.3
66	82	4.6
67	87	6.6
68	86	5.9
69	88	6.2
70	80	5.1
71	88	7.0
72	83	5.3
73	89	6.8
74	81	4.9
75	81	5.5
76	80	4.5
77	81	4.5
78	82	5.0
79	83	5.1
80	91	7.4
81	93	7.9
82	86	6.1
83	95	8.8
84	83	5.1
85	84	6.3
86	89	6.8
87	84	6.0
88	87	6.3
89	90	7.2
90	90	7.1
91	83	5.8
92	92	7.5
93	89	6.8
94	84	6.0
95	85	6.0
96	81	5.7
97	82	5.0
98	87	6.6
99	89	6.5
100	84	6.0
101	89	6.3
102	80	4.8
103	82	5.5
104	80	4.4
105	94	7.9
106	85	5.4
107	88	6.2
108	86	6.1
109	88	7.6
110	80	4.6
111	80	4.7
112	86	6.4
113	80	5.2
114	83	5.3
115	83	5.2
116	80	4.9
117	83	5.2
118	90	7.3
119	82	5.4
120	92	7.6
121	85	6.2
122	83	5.3
123	90	7.0
124	94	7.7
125	84	6.1
126	88	6.0
127	82	5.3
128	85	6.5
129	87	5.8
130	80	4.5
131	83	5.6
132	84	5.2
133	80	4.6
134	80	5.3
135	91	7.5
136	82	5.1
137	89	6.6
138	84	4.5
139	83	6.0
140	80	4.7
141	85	5.2
142	85	5.9
143	86	6.5
144	86	5.9
145	89	7.3
146	81	4.6
147	86	6.3
148	95	8.1
149	87	5.9
150	82	5.0

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon for the injection exposure to PAHs.

Treatment: PAHs
Date: 7/9/97

Tank: 7

Fish#	Length	Weight
151	80	4.7
152	89	6.9
153	85	5.0
154	80	5.0
155	83	6.0
156	82	5.4
157	85	5.5
158	87	7.2
159	81	4.6
160	83	5.7
161	92	7.1
162	91	7.8
163	89	6.8
164	85	5.3
165	83	5.8
166	81	5.0
167	82	5.0
168	82	5.6
169	88	6.4
170	85	6.1
171	87	6.4
172	84	6.3
173	87	7.1
174	87	6.5
175	92	8.6
176	82	5.5
177	80	4.7
178	92	7.3
179	82	5.2
180	86	6.4
181	87	6.2
182	91	7.7
183	82	5.5
184	82	5.3
185	83	5.3
186	89	6.7
187	89	6.5
188	91	6.8

Fish#	Length	Weight
189	81	4.9
190	85	6.0
191	83	5.5
192	84	5.3
193	88	7.3
194	83	6.0
195	89	7.0
196	91	7.6
197	94	8.4
198	94	8.0
199	86	5.6
200	89	7.3
201	86	6.5
202	90	7.8
203	88	7.6
204	82	5.6
205	82	5.8
206	88	7.1
207	82	5.2
208	86	4.9
209	84	5.7
210	82	5.0
211	85	6.1
212	84	6.2
213	80	5.0
214	87	5.7
215	82	5.0
216	86	6.4
217	81	5.0
218	84	5.8
219	83	5.3
220	89	6.9
221	84	5.7
222	87	7.0
223	84	6.5
224	91	7.3
225	83	5.8
226	87	6.8

Fish#	Length	Weight
227	90	6.6
228	81	5.2
229	85	6.0
230	86	6.3
231	83	5.6
232	86	6.3
233	86	6.0
234	95	8.2
235	88	6.9
236	90	6.8
237	82	4.9
238	85	6.2
239	88	6.6
240	85	4.5
241	80	5.1
242	88	7.0
243	83	5.2
244	83	5.7
245	95	8.5
246	84	5.2
247	89	6.8
248	87	5.8
249	88	6.0
250	88	6.9
251	90	6.9
252	84	5.6
253	85	5.5
254	90	6.8
255	81	5.0
256	86	5.9
257	85	5.7
258	82	5.4
259	87	6.2
260	81	5.3
261	81	5.0
262	80	5.6
263	84	6.2
264	86	5.8

Fish#	Length	Weight
265	86	6.3
266	81	4.7
267	89	6.8
268	88	6.1
269	89	6.8
270	92	8.0
271	81	5.4
272	83	6.0
273	86	6.0
274	84	5.2
275	86	6.6
276	84	5.7
277	82	5.2
278	81	4.6
279	81	5.2
280	90	6.8
281	88	5.9
282	85	5.9
283	88	6.5
284	83	5.8
285	88	6.7
286	81	5.1
287	89	7.1
288	80	4.9
289	80	5.1
290	89	7.1
291	84	5.6
292	87	6.3
293	84	6.3
294	81	4.7
295	90	6.4
296	85	5.9
297	97	8.4
298	81	4.9
299	90	6.6
300	95	8.2

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon, exposed to PAHs in the Biomarker study, sampled at 6 d post exposure.

Treatment: PAHs Tank: 7
Date: 7/15/97

Fish#	Length	Weight	Fish#	Length	Weight	Fish#	Length	Weight
1	83	5.8	38	86	7.4	75	90	7.2
2	90	7.9	39	80	5.5			
3	81	4.9	40	83	6.8			
4	84	5.9	41	82	5.7			
5	86	7.5	42	85	5			
6	89	7.5	43	81	5.3			
7	88	7	44	80	5.2			
8	97	9.2	45	87	6.6			
9	90	9.2	46	80	5			
10	88	6.6	47	98	11			
11	93	8.9	48	80	5.2			
12	92	8.4	49	89	7.1			
13	87	6.1	50	92	6.2			
14	83	6.2	51	92	8.4			
15	81	5.3	52	95	8.8			
16	90	7.8	53	81	5.8			
17	89	8	54	81	6.1			
18	82	6.4	55	85	6.3			
19	90	7.5	56	84	6.9			
20	80	4.8	57	85	7.6			
21	81	5.7	58	85	6.5			
22	88	7.3	59	85	6.4			
23	89	6.1	60	85	7.3			
24	89	7.1	61	85	7.2			
25	83	6.2	62	80	5			
26	81	5.9	63	86	7			
27	90	6.8	64	86	7.1			
28	87	6.6	65	83	6.2			
29	86	6.2	66	83	5.5			
30	88	6.8	67	84	6			
31	80	6	68	90	8			
32	82	6.6	69	90	8.5			
33	89	7.5	70	81	5.8			
34	82	5.8	71	83	6			
35	83	6.1	72	85	6.2			
36	86	7.3	73	82	6.1			
37	93	9.6	74	80	5			

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon, exposed to PAHs in the Biomarker study, sampled at 20 d post exposure.

Treatment: PAHs Tank: 7
Date: 7/29/97

Fish#	Length	Weight
1	82	5.3
2	92	7.9
3	89	6.4
4	88	7.2
5	87	6.6
6	84	5.8
7	86	7.0
8	87	6.7
9	101	10.5
10	98	10.5
11	94	9.3
12	93	8.9
13	92	8.4
14	87	7.0
15	92	8.9
16	88	7.8
17	92	8.6
18	90	7.5
19	86	7.1
20	85	5.5
21	93	8.8
22	94	8.9
23	86	6.8
24	86	6.8
25	92	8.3
26	92	8.7
27	95	9.2
28	93	8.3
29	96	9.8
30	94	8.7
31	94	9.0
32	93	9.0
33	89	7.7
34	83	6.0
35	87	6.8
36	84	6.6
37	92	8.4

Fish#	Length	Weight
38	85	6.6
39	90	7.9
40	84	6.7
41	93	6.1
42	95	9.8
43	91	8.2
44	85	6.9
45	89	8.0
46	86	6.7
47	85	6.6
48	89	7.2
49	87	7.4
50	97	10.4
51	82	5.8
52	90	8.8
53	91	8.1
54	87	5.9
55	93	8.3
56	90	7.6
57	86	7.1
58	89	7.3
59	81	5.0
60	88	6.6
61	86	6.4
62	91	8.0
63	95	9.6
64	83	5.7
65	105	13.1
66	84	5.9
67	88	7.4
68	82	5.3
69	83	5.7
70	92	8.6
71	89	8.4
72	84	6.6
73	89	7.7
74	90	7.4

Fish#	Length	Weight
75	83	5.7
76	90	7.4
77	85	6.6
78	94	9.5
79	94	9.3
80	89	8.2
81	95	9.9
82	85	5.8
83	88	7.1
84	94	8.8
85	92	9.0

Persistence and selectivity of biomarker responses in juvenile chinook salmon exposed to chemical contaminants specific to the Hylebos Waterway.

Lengths and weights of juvenile chinook salmon, exposed to PAHs in the Biomarker study, sampled at 60 d post exposure.

Treatment: PAHs Tank: 7
Date: 9/9/97

Fish#	Length	Weight	Fish#	Length	Weight
1	116	17.8	38	104	13.2
2	119	21.5	39	108	15.5
3	91	9.3	40	102	12.0
4	114	17.7	41	118	20.0
5	111	17.5	42	99	12.2
6	106	16.4	43	111	17.3
7	95	12.2	44	103	13.5
8	114	17.6	45	114	17.4
9	101	12.0	46	111	16.8
10	111	17.5	47	109	14.8
11	118	17.8	48	108	14.5
12	101	12.6	49	109	15.0
13	113	18.2	50	114	17.8
14	114	19.4	51	98	12.3
15	115	19.2	52	114	19.5
16	119	21.0	53	103	12.8
17	107	14.4	54	113	16.7
18	116	20.1	55	116	18.5
19	109	16.5	56	99	10.4
20	124	22.7	57	97	11.6
21	112	16.9	58	97	11.7
22	112	16.9	59	95	10.7
23	92	9.5	60	96	10.1
24	113	18.7	61	106	14.2
25	116	18.7	62	111	15.6
26	106	14.0	63	104	12.7
27	105	16.3	64	98	11.4
28	111	16.8	65	106	14.9
29	104	13.8	66	117	18.3
30	100	11.8	67	101	12.4
31	96	10.8	68	92	9.3
32	109	15.9	69	116	18.7
33	125	24.2	70	115	18.8
34	121	21.2	71	106	13.8
35	101	11.8	72	113	17.1
36	116	21.1	73	108	14.3
37	104	13.3	74	93	9.3

Hylebos Fish Injury Study - Round II, Part 3
Individual Data and Quality Assurance Results
CASE NARRATIVE

Juvenile Salmon Biomarker Response Studies

Biliary FACs - measured as benzo[a]pyrene equivalents (Table 1)

Composites of bile samples from juvenile chinook salmon (*Oncorhynchus tshawytscha*) for the Biomarker study part of the Puget Sound Salmon Damage Assessment 1997 study were analyzed by HPLC with fluorescence detection in one set. Benzo(a)pyrene- (BAP), naphthalene- (NPH) and phenanthrene- (PHN) like fluorescence responses were measured. In accordance with the Sampling and Analysis Plan (SAP), analytical quality control (identified by QCBatch) was assessed with each analysis. For the salmon studies, the QCBatch identification for the analysis set is BILE428+/433/436.

Method Blank

Results of the HPLC analysis of the methods for QCBatch showed fluorescence responses of BaP, NPH and PHN met the following criteria: BaP, NPH, or PHN equivalents in the method blanks were less than 10% of concentrations in any bile sample analyzed in the same set.

Initial Calibration Standards

An initial calibration standard consisting of known concentrations of BaP, NPH and PHN was analyzed in duplicate at the start of each sample set. The relative standard deviation (RSD) for each individual PAH for the two analyses met the criteria ($\leq$15%) set in the quality control section (Table 4) of the SAP.

Continuing Calibration Standards

The calibration standard was analyzed periodically throughout the sample sets. The relative standard deviation for the analyses was within the 25% RSD limit set for each individual PAH (Table 4, SAP).

Bile Reference Material

A bile reference material was analyzed near the beginning and end of each sample set and compared to historical interlaboratory means of this reference (see Quality Assurance section in SAP). The measured fluorescence responses of this bile sample were determined to be within the upper and lower control limit of the interlaboratory mean value for this reference bile (see Quality Assurance Results).

Replicates

Selected bile samples were analyzed in duplicate for every ten fish analyzed. The RSDs ranged from 2 to 37 %, which is within the 50% RSD set in the SAP.

Commentary on Sample Analyses

Samples DA01-0715, DA08-0715, DA10-0715, DA100-0813 and DA101-0813 were reanalyzed because the chromatograms were not sufficiently resolved for quantitation. The reanalyzed samples are covered under QCBatch identification BILE433+. Results of FAC analyses shown in Table 1 are from fish sampled at different time points in the biomarker study, and 60 d post exposure (8/25/97) in the growth study (labeled as 60 days growth study).

Table 1
Hylebos Waterway Fish Injury Studies

A/E

06 days		Rep#	ng/gm bile BaP	ng/gm bile NPH	ng/gm bile PHN	PROTEIN	PROTEIN CORRECTED (ng/mg protein) BaP	PROTEIN CORRECTED (ng/mg protein) NPH	PROTEIN CORRECTED (ng/mg protein) PHN
DA01_0715	B43342	1	521	165,164	88,361	13.7	38	12,056	6,450
DA02	B42807	1	205	37,327	14,446	9.9	21	3,770	1,459
DA03	B42808	1	248	45,133	15,714	6.2	40	7,280	2,535
		Average	325	82,541	39,507		33	7,702	3,481
		± SD	140	58,510	34,549		9	3,396	2,145

20 days		Rep#	ng/gm bile BaP	ng/gm bile NPH	ng/gm bile PHN	PROTEIN	PROTEIN CORRECTED (ng/mg protein) BaP	PROTEIN CORRECTED (ng/mg protein) NPH	PROTEIN CORRECTED (ng/mg protein) PHN
DA43_0729	B42830	1	57	44,944	12,999	5.0	11	8,989	2,600
DA44	B42832	1	149	37,268	11,328	5.0	30	7,454	2,266
DA45	B42834	1	111	59,325	18,032	5.0	22	11,865	3,606
		Average	106	47,179	14,120		21	9,436	2,824
		± SD	38	9,142	2,849		8	1,828	570

35 days		Rep#	ng/gm bile BaP	ng/gm bile NPH	ng/gm bile PHN	PROTEIN	PROTEIN CORRECTED (ng/mg protein) BaP	PROTEIN CORRECTED (ng/mg protein) NPH	PROTEIN CORRECTED (ng/mg protein) PHN
DA100_813	B43348	1	337	48,700	23,161	7.7	44	6,325	3,008
DA101_813	B43350	1	302	38,567	20,266	7.0	43	5,510	2,895
DA102	B43009	1	235	50,291	19,860	6.3	37	8,459	3,152
		Average	291	46,853	21,096		41	6,764	3,018
		± SD	42	6,151	1,470		3	1,244	105

60 days growth		Rep#	ng/gm bile BaP	ng/gm bile NPH	ng/gm bile PHN	PROTEIN	PROTEIN CORRECTED (ng/mg protein) BaP	PROTEIN CORRECTED (ng/mg protein) NPH	PROTEIN CORRECTED (ng/mg protein) PHN
23_0825 60 days	B43120	1	163	42,926	11,604	2.9	56	14,802	4,001
24_0825 60 days	B43121	1	155	40,397	10,290	3.5	44	11,542	2,940
25_0825 60 days	B43122	1	121	36,423	9,126	2.8	43	13,008	3,259
26_0825 60 days	B43123	1	124	41,774	10,480	5.4	23	7,736	1,941
		Average	141	40,380	10,375		42	11,772	3,035
		± SD	18	2,454	879		12	2,601	740

HCBD

06 days		Rep#	ng/gm bile BaP	ng/gm bile NPH	ng/gm bile PHN	PROTEIN	PROTEIN CORRECTED (ng/mg protein) BaP	PROTEIN CORRECTED (ng/mg protein) NPH	PROTEIN CORRECTED (ng/mg protein) PHN
DA13	B42820	1	240	38,391	13,309	7.4	32	5,188	1,799
DA14	B42821	1	219	52,821	19,234	6.9	32	7,655	2,788
DA15	B42822	1	241	54,027	13,871	8.3	29	6,509	1,671
		Average	233	48,413	15,471		31	6,451	2,086
		± SD	10	7,104	2,670		1	1,008	499

20 days		Rep#	ng/gm bile BaP	ng/gm bile NPH	ng/gm bile PHN	PROTEIN	PROTEIN CORRECTED (ng/mg protein) BaP	PROTEIN CORRECTED (ng/mg protein) NPH	PROTEIN CORRECTED (ng/mg protein) PHN
DA58	B42919	1	123	34,702	7,885	3.9	32	8,898	2,022
DA59	B42920	1	137	35,246	8,061	3.3	42	10,681	2,443
DA60	B42921	1	143	36,829	7,462	5.1	28	7,614	1,463

Table 1

		Average	134	36,259	7,803		34	9,064	1,976
		± SD	8	1,831	251		6	1,258	401

			ng/gm bile				PROTEIN CORRECTED (ng/mg protein)		
56 days		Rep#	BaP	NPH	PHN	PROTEIN	BaP	NPH	PHN
DA118	B43014	1	35	15,174	1,402	10.4	3	1,459	135
DA120	B43015	1	30	14,974	1,340	14.3	2	1,047	94
		Average	33	15,074	1,371		3	1,253	114
		± SD	3	100	31		1	206	21

			ng/gm bile				PROTEIN CORRECTED (ng/mg protein)		
60 days growth		Rep#	BaP	NPH	PHN	PROTEIN	BaP	NPH	PHN
970825-31	B43648	1	259	45,451	11,052	10.7	24	4,248	1,033
970825-32	B43649	1	214	23,434	5,439	5.8	37	4,040	938
970825-33	B43650	1	194	29,202	5,459	4.4	44	6,637	1,241
970825-34	B43651	1	152	19,867	4,651	5.2	29	3,821	894
		Average	205	29,489	6,650		34	4,686	1,026
		± SD	38	9,799	2,562		8	1,136	133

HWSE-M

			ng/gm bile				PROTEIN CORRECTED (ng/mg protein)		
06 days		Rep#	BaP	NPH	PHN	PROTEIN	BaP	NPH	PHN
DA07	B42813	1	317	61,762	18,316	8.4	38	7,353	2,180
DA08_0715	B43346	1	396	32,578	17,059	8.2	48	3,973	2,080
		Average	357	47,170	17,688		43	5,663	2,130
		± SD	40	14,592	629		5	1,690	50

			ng/gm bile				PROTEIN CORRECTED (ng/mg protein)		
20 days		Rep#	BaP	NPH	PHN	PROTEIN	BaP	NPH	PHN
DA55	B42915	1	181	49,456	10,563	6.3	29	7,850	1,677
DA56	B42916	1	218	59,562	12,653	5.9	37	10,095	2,145
DA57	B42918	1	164	47,273	9,057	6.8	24	6,952	1,332
		Average	188	52,097	10,758		30	8,299	1,718
		± SD	23	5,353	1,474		5	1,322	333

			ng/gm bile				PROTEIN CORRECTED (ng/mg protein)		
33 days		Rep#	BaP	NPH	PHN	PROTEIN	BaP	NPH	PHN
DA85	B42926	1	184	51,496	10,784	13.0	14	3,961	830
DA86	B42927	1	328	68,074	15,791	13.5	24	5,043	1,170
DA87	B42928	1	205	48,503	11,028	9.6	21	5,052	1,149
		Average	239	56,024	12,534		20	4,685	1,049
		± SD	64	8,608	2,305		4	512	156

			ng/gm bile				PROTEIN CORRECTED (ng/mg protein)		
60 days growth		Rep#	BaP	NPH	PHN	PROTEIN	BaP	NPH	PHN
11_0825 60 days	B43030	1	109	31,251	7,739	5.1	21	6,128	1,517
12_0825 60 days	B43032	1	97	41,286	6,874	3.7	26	11,158	1,858
13_0825 60 days	B43034	1	106	53,867	7,412	4.1	26	13,138	1,808
14_0825 60 days	B43036	1	100	43,814	6,010	3.4	29	12,886	1,768

Table 1

	Average	103	42,555	7,009		26	10,828	1,738
	± SD	5	8,046	654		3	2,819	131

HWSE-P

			ng/gm bile				PROTEIN CORRECTED (ng/mg protein)		
06 days		Rep#	BaP	NPH	PHN	PROTEIN	BaP	NPH	PHN
DA11	B42818	1	173	33,377	9,994	3.7	47	9,021	2,701
DA12	B42819	1	156	34,441	12,127	7.4	21	4,654	1,639
	Average		165	33,909	11,061		34	6,838	2,170
	± SD		9	532	1,067		13	2,183	531

			ng/gm bile				PROTEIN CORRECTED (ng/mg protein)		
20 days		Rep#	BaP	NPH	PHN	PROTEIN	BaP	NPH	PHN
DA52	B42912	1	205	42,362	8,308	7.1	29	5,966	1,170
DA53	B42913	1	127	39,343	7,579	9.7	13	4,056	781
DA54	B42914	1	170	45,654	9,922	6.0	28	7,609	1,654
	Average		167	42,453	8,603		23	5,877	1,202
	± SD		32	2,577	979		7	1,452	357

			ng/gm bile				PROTEIN CORRECTED (ng/mg protein)		
56 days		Rep#	BaP	NPH	PHN	PROTEIN	BaP	NPH	PHN
DA106_0903	B43011	1	112	35,512	9,803	4.7	24	7,556	2,086
DA107	B43012	1	83	38,799	6,441	7.0	12	5,543	920
DA108	B43013	1	113	47,570	9,375	4.6	25	10,341	2,038
	Average		103	40,627	8,540		20	7,813	1,681
	± SD		14	5,090	1,494		6	1,967	539

			ng/gm bile				PROTEIN CORRECTED (ng/mg protein)		
60 days growth		Rep#	BaP	NPH	PHN	PROTEIN	BaP	NPH	PHN
15_0825 60 days	B43111	1	137	44,991	12,412	4.1	33	10,973	3,027
16_0825 60 days	B43112	1	126	48,781	13,412	4.8	26	10,163	2,794
17_0825 60 days	B43113	1	149	45,594	12,459	4.3	35	10,603	2,897
18_0825 60 days	B43114	1	116	31,619	7,577	3.2	36	9,881	2,368
	Average		132	42,746	11,465		33	10,405	2,772
	± SD		12	6,584	2,280		4	417	247

None

			ng/gm bile				PROTEIN CORRECTED (ng/mg protein)		
0		Rep#	BaP	NPH	PHN	PROTEIN	BaP	NPH	PHN
01_0626	B43018	1	152	40,262	6,453	3.6	42	11,184	1,793
02_0626	B43019	1	175	41,672	7,523	4.5	39	9,260	1,672
03_0626	B43020	1	157	42,445	6,891	5.6	28	7,579	1,231
DA001_0710	B43021	1	146	44,052	8,608	5.0	29	8,810	1,722
DA002	B43022	1	138	50,315	8,088	5.2	27	9,676	1,555
DA003	B43023	1	150	38,307	9,914	4.9	31	7,818	2,023
	Average		153	42,842	7,913		33	9,055	1,666
	± SD		11	3,787	1,144		6	1,206	241

Table 1

NOSE

06 days		Reps	ng/gm bile BaP	NPH	PHN	PROTEIN	PROTEIN CORRECTED (ng/mg protein) BaP	NPH	PHN
DA04	B42809	1	206	49,273	14,076	8.2	25	6,009	1,717
DA05	B42811	1	297	48,918	14,498	7.4	40	6,611	1,959
DA06	B42812	1	281	52,064	16,401	10.4	27	5,006	1,577
		Average	261	50,085	14,992		31	5,875	1,751
		± SD	40	1,407	1,011		7	662	158

20 days		Reps	ng/gm bile BaP	NPH	PHN	PROTEIN	PROTEIN CORRECTED (ng/mg protein) BaP	NPH	PHN
DA46	B42929	1	164	47,206	9,116	8.2	20	5,757	1,112
DA47	B42836	1	94	44,939	13,660	7.1	13	6,329	1,924
DA48 R	B43007	1	139	45,309	9,541	5.2	27	8,713	1,835
		Average	132	45,818	10,772		20	6,933	1,623
		± SD	29	993	2,049		6	1,280	364

33 days		Reps	ng/gm bile BaP	NPH	PHN	PROTEIN	PROTEIN CORRECTED (ng/mg protein) BaP	NPH	PHN
DA91_0811	B42930	1	286	68,018	14,293	11.7	24	5,814	1,222
DA92	B42932	1	151	45,511	8,638	5.9	26	7,714	1,464
DA93	B42934	1	629	135,756	25,398	6.0	105	22,626	4,233
		Average	355	83,095	16,110		52	12,051	2,306
		± SD	201	38,354	6,962		38	7,518	1,366

60 days growth		Reps	ng/gm bile BaP	NPH	PHN	PROTEIN	PROTEIN CORRECTED (ng/mg protein) BaP	NPH	PHN
27_0825 60 days	B43125	1	135	38,324	9,836	3.4	40	11,272	2,893
28_0825 60 days	B43126	1	148	47,860	13,249	9.3	16	5,146	1,425
29_0825 60 days	B43127	1	126	44,094	11,498	8.5	15	5,188	1,353
30_0825 60 days	B43128	1	125	41,923	10,907	2.9	43	14,456	3,761
		Average	134	43,050	11,373		28	9,015	2,358
		± SD	9	3,458	1,236		13	4,010	1,017

PAHs

06 days		Reps	ng/gm bile BaP	NPH	PHN	PROTEIN	PROTEIN CORRECTED (ng/mg protein) BaP	NPH	PHN
DA16	B42823	1	452	47,309	12,107	4.8	94	9,856	2,522
DA17	B42825	1	273	47,238	15,357	7.5	36	6,298	2,048
DA18	B42826	1	291	35,269	10,720	4.5	65	7,838	2,382
		Average	339	43,272	12,728		65	7,997	2,317
		± SD	80	5,659	1,943		24	1,457	199

20 days		Reps	ng/gm bile BaP	NPH	PHN	PROTEIN	PROTEIN CORRECTED (ng/mg protein) BaP	NPH	PHN
DA49	B42908	1	145	41,046	8,975	4.6	32	8,923	1,951
DA50	B42909	1	186	44,214	9,116	6.9	27	6,408	1,321
DA51	B42911	1	188	48,635	10,528	7.0	27	6,948	1,504

Table 1

		Average	173	44,632	9,540		28	7,426	1,592
		± SD	20	3,112	701		2	1,081	265

			ng/gm bile				PROTEIN CORRECTED (ng/mg protein)		
60 days growth		**Rep#**	**BaP**	**NPH**	**PHN**	**PROTEIN**	**BaP**	**NPH**	**PHN**
19_0825 60 days	B43115	1	133	38,170	9,908	2.9	46	13,162	3,417
20_0825 60 days	B43116	1	121	44,240	11,792	5.8	21	7,628	2,033
21_0825 60 days	B43118	1	154	41,893	11,227	2.6	59	16,113	4,318
22_0825 60 days	B43119	1	155	45,336	11,874	3.4	46	13,334	3,492
		Average	141	42,410	11,200		43	12,559	3,315
		± SD	14	2,746	787		14	3,079	820

			ng/gm bile				PROTEIN CORRECTED (ng/mg protein)		
62 days		**Rep#**	**BaP**	**NPH**	**PHN**	**PROTEIN**	**BaP**	**NPH**	**PHN**
DA121_0909	B43016	1	106	42,408	8,052	8.2	13	5,172	982
DA122_0909	B43025	1	109	49,685	6,370	7.4	15	6,714	861
DA123	B43026	1	97	49,335	6,453	6.3	15	7,831	1,024
		Average	104	47,143	6,958		14	6,572	956
		± SD	5	3,351	774		1	1,090	69

PCBs

			ng/gm bile				PROTEIN CORRECTED (ng/mg protein)		
06 days		**Rep#**	**BaP**	**NPH**	**PHN**	**PROTEIN**	**BaP**	**NPH**	**PHN**
DA19	B42827	1	206	40,919	12,438	6.0	34	6,820	2,073
DA20	B42828	1	231	52,371	13,567	7.2	32	7,274	1,884
DA21	B42829	1	242	49,462	11,315	5.2	47	9,512	2,176
		Average	226	47,584	12,440		38	7,869	2,044
		± SD	15	4,860	919		6	1,177	121

			ng/gm bile				PROTEIN CORRECTED (ng/mg protein)		
20 days		**Rep#**	**BaP**	**NPH**	**PHN**	**PROTEIN**	**BaP**	**NPH**	**PHN**
DA61	B42922	1	153	36,205	7,967	3.5	44	10,344	2,276
DA62	B42923	1	143	44,283	9,980	5.0	29	8,857	1,996
DA63	B42925	1	150	36,566	9,104	3.9	38	9,381	2,334
		Average	149	39,025	9,017		37	9,527	2,202
		± SD	4	3,721	824		6	616	148

			ng/gm bile				PROTEIN CORRECTED (ng/mg protein)		
60 days growth		**Rep#**	**BaP**	**NPH**	**PHN**	**PROTEIN**	**BaP**	**NPH**	**PHN**
970825-07	B43642	1	195	21,736	6,446	5.5	35	3,952	1,172
970825-08	B43643	1	137	21,408	4,730	7.2	19	2,973	657
970825-09	B43644	1	166	23,847	6,842	5.9	28	4,042	1,160
970825-10	B43645	1	114	26,959	6,158	3.3	35	8,169	1,866
		Average	153	23,488	6,044		29	4,784	1,214
		± SD	30	2,212	797		7	1,999	430

			ng/gm bile				PROTEIN CORRECTED (ng/mg protein)		
62 days		**Rep#**	**BaP**	**NPH**	**PHN**	**PROTEIN**	**BaP**	**NPH**	**PHN**
DA124	B43027	1	92	41,561	5,062	3.9	24	10,657	1,298

Table 1

DA125	B43028	1	88	39,438	5,282	6.6	13	5,975	800
DA126	B43029	1	119	50,385	8,330	6.8	18	7,410	1,225
		Average	100	43,795	6,225		18	8,014	1,108
		± SD	14	4,740	1,491		4	1,958	219

ANOVA Output: Biliary FAC levels of biomarker study samples (6, 20, 33, 35, 56, and 60 d post exposure) and growth study samples (60 d post exposure).

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treament	6	1656.239	276.040	1.727	.1284
Time	6	6026.264	1004.377	6.285	.0001
Treament * Time	15	4669.636	311.309	1.948	.0335
Residual	66	10546.333	159.793		

Dependent: BAP/Prot

Means Table
Effect: Treament * Time
Dependent: BAP/Prot

	Count	Mean	Std. Dev.	Std. Error
None, 0 day	6	32.667	6.282	2.565
A/E, 06 days	3	33.000	10.440	6.028
A/E, 20 days	3	21.000	9.539	5.508
A/E, 35 days	3	41.333	3.786	2.186
A/E, 60 days	4	41.500	13.675	6.837
HCBD, 06 days	3	31.000	1.732	1.000
HCBD, 20 days	3	34.000	7.211	4.163
HCBD, 60 days	4	33.500	8.813	4.406
HCBD, 56 days	2	2.500	.707	.500
HWSE-M, 06 days	2	43.000	7.071	5.000
HWSE-M, 20 days	3	30.000	6.557	3.786
HWSE-M, 60 days	4	25.500	3.317	1.658
HWSE-M, 33 days	3	19.667	5.132	2.963
HWSE-P, 06 days	2	34.000	18.385	13.000
HWSE-P, 20 days	3	23.667	9.238	5.333
HWSE-P, 60 days	4	32.500	4.509	2.255
HWSE-P, 56 days	3	20.333	7.234	4.177
NQSE, 06 days	3	30.667	8.145	4.702
NQSE, 20 days	3	20.000	7.000	4.041
NQSE, 60 days	4	28.500	15.067	7.533
NQSE, 33 days	3	51.667	46.199	26.673
PAHs, 06 days	3	65.000	29.000	16.743
PAHs, 20 days	3	28.667	2.887	1.667
PAHs, 60 days	4	43.000	15.895	7.948
PAHs, 62 days	3	14.333	1.155	.667
PCBs, 06 days	3	37.667	8.145	4.702
PCBs, 20 days	3	37.000	7.550	4.359
PCBs, 60 days	4	29.250	7.588	3.794
PCBs, 62 days	4	18.250	4.500	2.250

from both biomarker and growth studies

ANOVA Output: Treatment Effects (SuperANOVA, Abacus Concepts Inc., Berkeley, CA).
Biliary FAC levels at 6 d post exposure.

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treament	6	2622.351	437.058	2.049	.1367
Residual	12	2559.333	213.278		

Dependent: BAP/Prot

Means Table
Effect: Treament
Dependent: BAP/Prot

	Count	Mean	Std. Dev.	Std. Error
A/E	3	33.000	10.440	6.028
HCBD	3	31.000	1.732	1.000
HWSE-M	2	43.000	7.071	5.000
HWSE-P	2	34.000	18.385	13.000
NOSE	3	30.667	8.145	4.702
PAHs	3	65.000	29.000	16.743
PCBs	3	37.667	8.145	4.702

Dunnett Two-Tailed
Effect: Treament
Dependent: BAP/Prot
Significance level: .05

	Vs.	Diff.	Crit. diff.
A/E	NOSE	-2.333	35.534
	HCBD	-2.000	35.534
	HWSE-P	1.000	39.728
	PCBs	4.667	35.534
	HWSE-M	10.000	39.728
	PAHs	32.000	35.534

None were significantly different at this level.

ANOVA Output: Treatment Effects (SuperANOVA, Abacus Concepts Inc., Berkeley, CA).
Biliary FAC levels at 20 d post exposure.

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treament	6	758.476	126.413	2.294	.0941
Residual	14	771.333	55.095		

Dependent: BAP/Prot

Means Table
Effect: Treament
Dependent: BAP/Prot

	Count	Mean	Std. Dev.	Std. Error
A/E	3	21.000	9.539	5.508
HCBD	3	34.000	7.211	4.163
HWSE-M	3	30.000	6.557	3.786
HWSE-P	3	23.667	9.238	5.333
NQSE	3	20.000	7.000	4.041
PAHs	3	28.667	2.887	1.667
PCBs	3	37.000	7.550	4.359

Dunnett Two-Tailed
Effect: Treament
Dependent: BAP/Prot
Significance level: .05

	Vs.	Diff.	Crit. diff.
A/E	NQSE	-1.000	17.636
	HWSE-P	2.667	17.636
	PAHs	7.667	17.636
	HWSE-M	9.000	17.636
	HCBD	13.000	17.636
	PCBs	16.000	17.636

None were significantly different at this level.

ANOVA Output: Treatment Effects (SuperANOVA, Abacus Concepts Inc., Berkeley, CA).
Biliary FAC levels at 60 d post exposure.

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treament	6	1048.929	174.821	1.469	.2368
Residual	21	2499.750	119.036		

Dependent: BAP/Prot

Means Table
Effect: Treament
Dependent: BAP/Prot

	Count	Mean	Std. Dev.	Std. Error
A/E	4	41.500	13.675	6.837
HCBD	4	33.500	8.813	4.406
HWSE-M	4	25.500	3.317	1.658
HWSE-P	4	32.500	4.509	2.255
NQSE	4	28.500	15.067	7.533
PAHs	4	43.000	15.895	7.948
PCBs	4	29.250	7.588	3.794

Dunnett Two-Tailed
Effect: Treament
Dependent: BAP/Prot
Significance level: .05

	Vs.	Diff.	Crit. diff.
A/E	HWSE-M	-16.000	21.523
	NQSE	-13.000	21.523
	PCBs	-12.250	21.523
	HWSE-P	-9.000	21.523
	HCBD	-8.000	21.523
	PAHs	1.500	21.523

None were significantly different at this level.

Hylebos Fish Injury Study - Round II, Part 3
Individual Data and Quality Assurance Results
CASE NARRATIVE

Juvenile Salmon Biomarker Response Studies

DNA Adducts - measured as nmol DNA adducts/mol of nucleotides (Table 1)

Performance Evaluation
The standard used for ^{32}P-postlabeling DNA adducts, benzo[a]pyrene diolepoxide-dG (BaPDE-dG), met the ^{32}P-postlabeling criteria.

Calibration
There was no deviation from the QA/SAP calibration criteria. All of the calibration data used to quantitate DNA adducts met the initial and continuing criteria.

Method Blank
The QA/SAP criteria were met for the method blank in both sample sets.

Sample Duplicates
Four samples (2 samples per sample set) were processed and analyzed in duplicate. The relative standard deviations (RSD) ranged from 12% to 35%, which is within the 50% RSD set in the SAP. Every 17th sample was analyzed in duplicate, in contrast to the SAP which states that every 10th sample should be analyzed in duplicate. This decrease in the number of replicates was due to limited space per sample set.

Values reported that are less than 10 nmol adducts/mol nucleotide
If the storage phosphor images of the distribution of radioactivity on the chromatograms are sufficiently resolved and have a low background, then values less than 10 nmol DNA adducts/mol nucleotides for the large diagonal radioactive zone containing adducts derived from polycyclic aromatic compounds can be obtained. For the chromatography standard (BaPDE-dG), the limit of detection for a single, well-resolved spot is 0.1 nmol DNA adducts/mol nucleotides.

Commentary on Sample Analyses
DNA adducts were initially analyzed in fish exposed to HCBD at 6 days post exposure because adduct levels tend to decrease with time. DNA adducts were not observed on chromatograms from these HCBD-treated fish, so later timepoints were not measured. PCB-exposed fish were not analyzed because PCB-DNA adducts are not formed in detectable amounts. Table 1 contains DNA adduct data from juvenile salmon sampled at all timepoints during the Biomarker Response Study and Growth Study. Figures and statistics in the "Results" section of this report represent data from fish sampled at 6 and 20 days in the Biomarker Response Study and fish sampled at 60 days in the Growth Study. Data measured at these timepoints were used so that results between the various biomarkers could be compared.

Missing samples
One sample (#970825-23) was lost because sufficient DNA could not be extracted (Table 1).

Results from acetone/emulphor-injected fish
The DNA adduct profiles from the acetone/Emulphor (A/E) injected fish did not indicate any evidence of PAH exposure, however, parts of the chromatograms were very uncharacteristic of those normally generated in numerous past studies with fish injected with this solvent vehicle and this abnormality interfered with accurate quantitation. The reason for these chromatographic irregularities was not determined. However, the DNA adduct profiles and levels in the NQSE treated fish were highly representative of those typically observed in fish collected from uncontaminated sites, injected with uncontaminated sediment extracts or the solvent vehicle,

acetone/Emulphor in past studies (French et al. 1996, Stein et al. 1993). For these reasons the (A/E) injected fish were replaced with the reference sediment extract (NQSE) treated group (see Appendix 2) as the control group in the interpretation of the DNA damage data in this report.

DNA Adducts
Table 1 - Page 1

ppl#	set #	sample#	species	treatment	post exposure	nmol adducts/mol nucleotides
172-01	2	970710DA001	juvenile chinook	none	0 d	16
172-02	2	970710DA002	juvenile chinook	none	0 d	6
172-03	2	970710DA003	juvenile chinook	none	0 d	9
172-04	1	970715DA001	juvenile chinook	A/E	6d	47
172-05	1	970715DA002	juvenile chinook	A/E	6d	62
172-06	1	970715DA003	juvenile chinook	A/E	6d	41
172-07a	1	970729DA043	juvenile chinook	A/E	20d	36
172-07b	1	replicate	"	"	"	28
172-08	1	970729DA044	juvenile chinook	A/E	20d	45
172-09	1	970729DA045	juvenile chinook	A/E	20d	30
172-10a	2	970813DA100	juvenile chinook	A/E	35d	5
172-10b	2	replicate	"	"	"	7
172-11	2	970813DA101	juvenile chinook	A/E	35d	5
172-12	2	970813DA102	juvenile chinook	A/E	35d	11
172-13	2	970715DA010	juvenile chinook	HWSE-P	6d	27
172-14	2	970715DA011	juvenile chinook	HWSE-P	6d	27
172-15a	2	970715DA012	juvenile chinook	HWSE-P	6d	21
172-15b	2	replicate	"	"	"	25
172-16	2	970729DA052	juvenile chinook	HWSE-P	20d	32
172-17	2	970729DA053	juvenile chinook	HWSE-P	20d	6
172-18	2	970729DA054	juvenile chinook	HWSE-P	20d	5
172-19	2	970903DA106	juvenile chinook	HWSE-P	56d	7
172-20	2	970903DA107	juvenile chinook	HWSE-P	56d	7
172-21	2	970903DA108	juvenile chinook	HWSE-P	56d	17
172-31	2	970715DA007	juvenile chinook	HWSE-M	6d	19
172-32	2	970715DA008	juvenile chinook	HWSE-M	6d	22
172-33	2	970715DA009	juvenile chinook	HWSE-M	6d	36
172-34	2	970729DA055	juvenile chinook	HWSE-M	20d	12
172-35	2	970729DA056	juvenile chinook	HWSE-M	20d	10
172-36	2	970729DA057	juvenile chinook	HWSE-M	20d	14
172-37	2	970811DA085	juvenile chinook	HWSE-M	33d	13
172-38	2	970811DA086	juvenile chinook	HWSE-M	33d	14
172-39	2	970811DA087	juvenile chinook	HWSE-M	33d	10
172-40	1	970715DA004	juvenile chinook	NQSE	6d	3
172-41	1	970715DA005	juvenile chinook	NQSE	6d	2
172-42	1	970715DA006	juvenile chinook	NQSE	6d	3
172-43	2	970729DA046	juvenile chinook	NQSE	20d	5
172-44	1	970729DA047	juvenile chinook	NQSE	20d	6
172-45	1	970729DA048	juvenile chinook	NQSE	20d	2
172-49	1	970715DA016	juvenile chinook	PAHs	6d	37
172-50	2	970715DA017	juvenile chinook	PAHs	6d	28
172-51a	1	970715DA018	juvenile chinook	PAHs	6d	20
172-51b	1	replicate	"	"	"	31
172-52	1	970729DA049	juvenile chinook	PAHs	20d	41
172-53	2	970729DA050	juvenile chinook	PAHs	20d	23
172-54	1	970729DA051	juvenile chinook	PAHs	20d	26
172-55	1	970909DA121	juvenile chinook	PAHs	62d	4
172-56	1	970909DA122	juvenile chinook	PAHs	62d	10
172-57	1	970909DA123	juvenile chinook	PAHs	62d	3
172-58	2	970626-01	juvenile chinook	none	0d	9
172-59	2	970626-02	juvenile chinook	none	0d	9
172-60	2	970626-03	juvenile chinook	none	0d	6
172-61	2	970825-11	juvenile chinook	HWSE-M	60d	5
172-62	2	970825-12	juvenile chinook	HWSE-M	60d	4
172-63	2	970825-13	juvenile chinook	HWSE-M	60d	4
172-64	2	970825-14	juvenile chinook	HWSE-M	60d	8

DNA Adducts
Table 1 - Page 2

ppl#	set #	sample#	species	treatment	post exposure	nmol adducts/mol nucleotides
172-65	2	970825-15	juvenile chinook	HWSE-P	60d	3
172-66	2	970825-16	juvenile chinook	HWSE-P	60d	10
172-67	2	970825-17	juvenile chinook	HWSE-P	60d	2
172-68	2	970825-18	juvenile chinook	HWSE-P	60d	2
172-69	1	970825-19	juvenile chinook	PAHs	60d	8
172-70	1	970825-20	juvenile chinook	PAHs	60d	6
172-71	1	970825-21	juvenile chinook	PAHs	60d	7
172-72	1	970825-22	juvenile chinook	PAHs	60d	6
172-73	-	970825-23	juvenile chinook	A/E	60d	NDR
172-74	1	970825-24	juvenile chinook	A/E	60d	10
172-75	1	970825-25	juvenile chinook	A/E	60d	8
172-76	1	970825-26	juvenile chinook	A/E	60d	10
172-77	1	970825-27	juvenile chinook	NQSE	60d	3
172-78	1	970825-28	juvenile chinook	NQSE	60d	<10
172-79	1	970825-29	juvenile chinook	NQSE	60d	1
172-80	1	970825-30	juvenile chinook	NQSE	60d	2

ppl set #1	
salmon sperm DNA blank	3
Benzo[a]pyrene-DNA adduct standard - 5 ul	3
Benzo[a]pyrene-DNA adduct standard - 5 ul	3
Benzo[a]pyrene-DNA adduct standard - 10 ul	1
Benzo[a]pyrene-DNA adduct standard - 10 ul	2
deoxyadenosine (total nucleotide analysis standard) - 10 ul	8
deoxyadenosine (total nucleotide analysis standard) - 10 ul	11
ppl set #2	
salmon sperm DNA blank	2
Benzo[a]pyrene-DNA adduct standard - 5 ul	2.5
Benzo[a]pyrene-DNA adduct standard - 5 ul	3.4
Benzo[a]pyrene-DNA adduct standard - 10 ul	1.7
Benzo[a]pyrene-DNA adduct standard - 10 ul	1.7
deoxyadenosine (total nucleotide analysis standard) - 10 ul	14
deoxyadenosine (total nucleotide analysis standard) - 10 ul	14

NDR = no DNA recovered

Hepatic DNA Adduct results of biomarker study samples (6, 20, 33, 35, 56, and 62 d post exposure) and growth study samples (60 d post exposure).

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
treatment	4	4150.543	1037.636	31.346	.0001
"time post expo...	6	5804.554	967.426	29.225	.0001
treatment * "ti...	8	1699.791	212.474	6.419	.0001
Residual	47	1555.833	33.103		

Dependent: nmol DNA adducts/mol DNA nucleotides

Means Table
Effect: treatment * time post exposure (d)
Dependent: nmol DNA adducts/mol DNA nucleotides

	Count	Mean	Std. Dev.	Std. Error
none, 0	6	9.167	3.656	1.493
A/E, 6	3	50.000	10.817	6.245
A/E, 20	3	35.667	8.145	4.702
A/E, 35	3	7.333	3.215	1.856
A/E, 60	3	9.333	1.155	.667
HWSE-P, 6	3	25.667	2.309	1.333
HWSE-P, 20	3	14.333	15.308	8.838
HWSE-P, 56	3	10.333	5.774	3.333
HWSE-P, 60	4	4.250	3.862	1.931
HWSE-M, 6	3	25.667	9.074	5.239
HWSE-M, 20	3	12.000	2.000	1.155
HWSE-M, 33	3	12.333	2.082	1.202
HWSE-M, 60	4	5.250	1.893	.946
NQSE, 6	3	2.667	.577	.333
NQSE, 20	3	4.333	2.082	1.202
NQSE, 60	4	3.250	2.630	1.315
PAHs, 6	3	30.333	5.859	3.383
PAHs, 20	3	30.000	9.644	5.568
PAHs, 60	4	6.750	.957	.479
PAHs, 62	3	5.667	3.786	2.186

Hepatic DNA Adduct levels at 6 d post exposure

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
treatment	4	3407.067	851.767	17.795	.0002
Residual	10	478.667	47.867		

Dependent: nmol DNA adducts/mol DNA nucleotides

Means Table
Effect: treatment
Dependent: nmol DNA adducts/mol DNA nucleotides

	Count	Mean	Std. Dev.	Std. Error
A/E	3	50.000	10.817	6.245
HWSE-P	3	25.667	2.309	1.333
HWSE-M	3	25.667	9.074	5.239
NOSE	3	2.667	.577	.333
PAHs	3	30.333	5.859	3.383

Dunnett Two-Tailed
Effect: treatment
Dependent: nmol DNA adducts/mol DNA nucleotides
Significance level: .05

	Vs.	Diff.	Crit. diff.	
NOSE	HWSE-P	23.000	16.326	S
	HWSE-M	23.000	16.326	S
	PAHs	27.667	16.326	S
	A/E	47.333	16.326	S

S = Significantly different at this level.

Hepatic DNA Adduct levels at 20 d post exposure

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
treatment	4	2052.933	513.233	6.383	.0081
Residual	10	804.000	80.400		

Dependent: nmol DNA adducts/mol DNA nucleotides

Means Table
Effect: treatment
Dependent: nmol DNA adducts/mol DNA nucleotides

	Count	Mean	Std. Dev.	Std. Error
A/E	3	35.667	8.145	4.702
HWSE-P	3	14.333	15.308	8.838
HWSE-M	3	12.000	2.000	1.155
NOSE	3	4.333	2.082	1.202
PAHs	3	30.000	9.644	5.568

Dunnett Two-Tailed
Effect: treatment
Dependent: nmol DNA adducts/mol DNA nucleotides
Significance level: .05

	Vs.	Diff.	Crit. diff.	
NOSE	HWSE-M	7.667	21.158	
	HWSE-P	10.000	21.158	
	PAHs	25.667	21.158	S
	A/E	31.333	21.158	S

S = Significantly different at this level.

Hepatic DNA Adduct levels at 60 d post exposure (from growth study)

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
treatment	4	76.965	19.241	3.298	.0421
Residual	14	81.667	5.833		

Dependent: nmol DNA adducts/mol DNA nucleotides

Means Table
Effect: treatment
Dependent: nmol DNA adducts/mol DNA nucleotides

	Count	Mean	Std. Dev.	Std. Error
A/E	3	9.333	1.155	.667
HWSE-P	4	4.250	3.862	1.931
HWSE-M	4	5.250	1.893	.946
NOSE	4	3.250	2.630	1.315
PAHs	4	6.750	.957	.479

Dunnett Two-Tailed
Effect: treatment
Dependent: nmol DNA adducts/mol DNA nucleotides
Significance level: .05

	Vs.	Diff.	Crit. diff.	
NOSE	HWSE-P	1.000	4.697	
	HWSE-M	2.000	4.697	
	PAHs	3.500	4.697	
	A/E	6.083	5.073	S

S = Significantly different at this level.

Hylebos Fish Injury Study - Round II, Part 3
Individual Data and Quality Assurance Results
CASE NARRATIVE

Juvenile Salmon Biomarker Response Studies

Cytochrome P4501A - measured as aryl hydrocarbon hydroxylase (AHH) Activity . (Tables 1-3)

Microsomal Protein Standard Curve Calibration

Both criteria of the QAP were met for data used in this calibration. Standard curves for each sample set had regression coefficent (r^2) of ≥0.990 and each protein standard run in triplicate had RSD < 20%.

Method Blank

All three sample sets had a mean blank (calculated from 2 sets of duplicates) of greater than 50 dpm ^{14}C, therefore these sets do not meet the QAP guidelines outlined in table 4, for method blank QA. The CYP1A data must be qualified with respect to method blank. However, this does not affect the final data, as the mean blank values are corrected for in all samples.

Performance Evaluation

Triplicate analyses of each sample met the criteria as stated in the QAP of less than 30% RSD, for all values > 50 pmol/mg microsomal protein/minute.

Juvenile Salmon - Biomarker Studies

Analyses of Cytochrome P4501A [measured as aryl hydrocarbon hydroxylase(AHH) Activity]

Table 1 Notes

Microsomal Protein Standard Curve Calibration

The Microsome # (column heading abbr. µsome #), Protein sample #(column heading abbr. prot. sample#) and Sample #, are internal lab use numbers and for identification only. Column Final Liver Comp# is the official number assigned to each composited sample.

The number under Plate # column is the number assigned to each assay plate.

The concentrations of total protein were calculated using Bovine Albumin Serum (BSA) as the standard.

Column for Protein Standard concentrations (column abbr. Prot. Std. Conc #) identify each standard concentration dilution used : 2.0, 4.0, 8.0, 16.0, 20.0, and 30.0 mg/ml, with all standards loaded on plate as triplicates (e.g. 2.0-1, 2.0-2, 2.0-3 etc).

The Prot. Std OD value column is the absorbance of the sample measured as Optical Density (OD) at a wavelength of 620nm.

Percent coefficient of variation (column OD %CV) is standard deviation (SD) of each triplicate analyses (reported in Prot. Std OD value) divided by mean of each triplicate, multiplied by 100.

Correlation Coefficient (column abbr. Corr. Coeff.) is generated from linear standard curve fit of mean OD values of protein standards.

Sample Protein concentrations are given in column mg Prot./ml and are generated by automated interpolation from the standard curve fit of the mean OD values of protein standards.

µsome #	Sample #	Study	Trtmnt	Time	Plate #	Prot. Sample #	mg Prot. /ml	Protein Standard Curve Prot. Std. Conc.#	Prot.Std OD value	OD %CV (<20%)	Corr. Coeff. (>0.95)
97103001	970710DA001	Biomarker	none	0	971030, 971031	A01	14.4	2.0-1	0.263		0.997
97103002	970710DA002	Biomarker	none	0		A02	16.4	2.0-2	0.265		
97103003	970710DA003	Biomarker	none	0		A03	17.9	2.0-3	0.263	0.436	
97103004	970715DA01	Biomarker	A/E	6 day		A04	19.8	4.0-1	0.294		
97103005	970715DA02	Biomarker	A/E	6 day		A05	16.4	4.0-2	0.295		
97103006	970715DA03	Biomarker	A/E	6 day		A06	16.6	4.0-3	0.289	1.098	
97103007	970729DA43	Biomarker	A/E	20 day		A07	19.7	8.0-1	0.355		
97103008	970729DA44	Biomarker	A/E	20 day		A08	18.0	8.0-2	0.359		
97103009	970729DA45	Biomarker	A/E	20 day		A09	19.1	8.0-3	0.362	0.979	
97103010	970813DA100	Biomarker	A/E	35 day		A10	15.4	16.0-1	0.455		
97103011	970813DA101	Biomarker	A/E	35 day		A11	16.6	16.0-2	0.455		
97103012	970813DA102	Biomarker	A/E	35 day		A12	16.2	16.0-3	0.465	1.259	
97103101	970715DA10	Biomarker	HWSE-P	6 day		A13	17.4	20.0-1	0.496		
97103102	970715DA11	Biomarker	HWSE-P	6 day		A14	20.0	20.0-2	0.518		
97103103	970715DA12	Biomarker	HWSE-P	6 day		A15	17.3	20.0-3	0.515	2.341	
97103104	970729DA52	Biomarker	HWSE-P	20 day		A16	18.4	30.0-1	0.590		
97103105	970729DA53	Biomarker	HWSE-P	20 day		A17	16.9	30.0-2	0.528		
97103106	970729DA54	Biomarker	HWSE-P	20 day		A18	17.7	30.0-3	0.518	3.218	
97103107	970903DA106	Biomarker	HWSE-P	56 day		A19	21.1				
97103108	970903DA107	Biomarker	HWSE-P	56 day		A20	19.5				
97103109	970903DA108	Biomarker	HWSE-P	56 day		A21	21.2				Assay date
97103110	970715DA13	Biomarker	HCBD	6 day		A22	14.8				11/24/97
97103111	970715DA14	Biomarker	HCBD	6 day		A23	18.0				
97103112	970715DA15	Biomarker	HCBD	6 day		A24	15.4				
97110301	970729DA58	Biomarker	HCBD	20 day	Data 11-24 0002	A01	19.5	2.0-1	0.274		0.996
97110302	970729DA59	Biomarker	HCBD	20 day		A02	20.3	2.0-2	0.276		
97110303	970729DA60	Biomarker	HCBD	20 day		A03	19.6	2.0-3	0.271	0.92	
97110304	970903DA118	Biomarker	HCBD	56 day		A04	19.3	4.0-1	0.303		
97110305	970903DA119	Biomarker	HCBD	56 day		A05	18.8	4.0-2	0.295		
97110306	970903DA120	Biomarker	HCBD	56 day		A06	16.6	4.0-3	0.301	1.389	
97110307	970715DA07	Biomarker	HWSE-M	6 day		A07	17.5	8.0-1	0.364		
97110308	970715DA08	Biomarker	HWSE-M	6 day		A08	17.1	8.0-2	0.363		
97110309	970715DA09	Biomarker	HWSE-M	6 day		A09	15.0	8.0-3	0.365	0.272	

µsome #	Sample #	Study	Trtmnt	Time	Plate #	Prot. Sample #	mg Prot. /ml	Protein Standard Curve Prot. Std. Conc.#	Prot.Std OD value	OD %CV (<20%)	Corr. Coeff. (>0.95)
97110310	970729DA55	Biomarker	HWSE-M	20 day		A10	17.4	16.0-1	0.462		
97110311	970729DA56	Biomarker	HWSE-M	20 day		A11	11.1	16.0-2	0.463		
97110312	970729DA57	Biomarker	HWSE-M	20 day		A12	17.5	16.0-3	0.483	2.524	
97110601	970811DA85	Biomarker	HWSE-M	33 day		A13	20.6	20.0-1	0.504		
97110602	970811DA86	Biomarker	HWSE-M	33 day		A14	20.4	20.0-2	0.517		
97110603	970811DA87	Biomarker	HWSE-M	33 day		A15	21.7	20.0-3	0.513	1.302	
97110604	970715DA04	Biomarker	NQSE	6 day		A16	19.5	30.0-1	0.591		
97110605	970715DA05	Biomarker	NQSE	6 day		A17	16.4	30.0-2	0.616		Assay date
97110606	970715DA06	Biomarker	NQSE	6 day		A18	18.6	30.0-3	0.621	2.638	11/24/97
97110607	970729DA46	Biomarker	NQSE	20 day		A19	19.1				
97110608	970729DA47	Biomarker	NQSE	20 day		A20	16.4				
97110609	970729DA48	Biomarker	NQSE	20 day		A21	18.5				
97110610	970811DA91	Biomarker	NQSE	33 day		A22	21.6				
97110611	970811DA92	Biomarker	NQSE	33 day		A23	19.8				
97110612	970811DA93	Biomarker	NQSE	33 day		A24	19.7				
97111001	970715DA16	Biomarker	PAHs	6 day	971110, 971121	A01	18.6	2.0-1	0.265		0.992
97111002	970715DA17	Biomarker	PAHs	6 day		A02	20.6	2.0-2	0.259		
97111003	970715DA18	Biomarker	PAHs	6 day		A03	20.9	2.0-3	0.259	1.328	
97111004	970729DA49	Biomarker	PAHs	20 day		A04	21.6	4.0-1	0.267		
97111005	970729DA50	Biomarker	PAHs	20 day		A05	18.4	4.0-2	0.279		
97111006	970729DA51	Biomarker	PAHs	20 day		A06	20.0	4.0-3	0.271	2.243	
97111007	970909DA121	Biomarker	PAHs	62 day		A07	18.5	8.0-1	0.345		
97111008	970909DA122	Biomarker	PAHs	62 day		A08	19.2	8.0-2	0.347		
97111009	970909DA123	Biomarker	PAHs	62 day		A09	18.4	8.0-3	0.347	0.334	
97111010	970715DA19	Biomarker	PCBs	6 day		A10	18.1	16.0-1	0.424		
97111011	970715DA20	Biomarker	PCBs	6 day		A11	22.6	16.0-2	0.441		
97111012	970715DA21	Biomarker	PCBs	6 day		A12	18.7	16.0-3	0.437	2.048	
97111013	970729DA61	Biomarker	PCBs	20 day		A13	21.4	20.0-1	0.485		
97111014	970729DA62	Biomarker	PCBs	20 day		A14	21.9	20.0-2	0.498		
97111015	970729DA63	Biomarker	PCBs	20 day		A15	24.4	20.0-3	0.481	1.821	
97111016	970909DA124	Biomarker	PCBs	62 day		A16	22.2	30.0-1	0.545		
97111017	970909DA125	Biomarker	PCBs	62 day		A17	22.8	30.0-2	0.573		Assay date
97111018	970909DA126	Biomarker	PCBs	62 day		A18	22.3	30.0-3	0.569	2.693	12/12/98

µsome #	Sample #	Study	Trtmnt	Time	Plate #	Prot. Sample #	mg Prot. /ml	Protein Standard Curve Prot. Std. Conc.#	Prot.Std OD value	OD %CV (<20%)	Corr. Coeff. (>0.95)
97112001	97062601	Lab Growth	none	0		A19	21.6				
97112002	97062602	Lab Growth	none	0		A20	20.5				
97112003	97062603	Lab Growth	none	0		A21	24.2				
97112004	97082507	Lab Growth	PCBs	60 day		A22	25.4				
97112005	97082508	Lab Growth	PCBs	60 day		A23	23.9				
97112006	97082509	Lab Growth	PCBs	60 day		A24	24.9				
97112007	97082510	Lab Growth	PCBs	60 day	971120, 971121	A01	22.8	2.0-1	0.273		0.998
97112008	97082511	Lab Growth	HWSE-M	60 day		A02	22.7	2.0-2	0.27		
97112009	97082512	Lab Growth	HWSE-M	60 day		A03	21.6	2.0-3	0.267	1.111	
97112010	97082513	Lab Growth	HWSE-M	60 day		A04	20.8	4.0-1	0.298		
97112011	97082514	Lab Growth	HWSE-M	60 day		A05	23.5	4.0-2	0.293		
97112012	97082515	Lab Growth	HWSE-P	60 day		A06	21.5	4.0-3	0.297	0.895	
97112101	97082516	Lab Growth	HWSE-P	60 day		A07	20.3	8.0-1	0.347		
97112102	97082517	Lab Growth	HWSE-P	60 day		A08	21.9	8.0-2	0.361		
97112103	97082518	Lab Growth	HWSE-P	60 day		A09	23.8	8.0-3	0.358	2.074	
97112104	97082519	Lab Growth	PAHs	60 day		A10	22.7	16.0-1	0.433		
97112105	97082520	Lab Growth	PAHs	60 day		A11	19.7	16.0-2	0.432		
97112106	97082521	Lab Growth	PAHs	60 day		A12	20.8	16.0-3	0.431	0.23	
97112107	97082522	Lab Growth	PAHs	60 day		A13	22.2	20.0-1	0.456		
97112108	97082523	Lab Growth	A/E	60 day		A14	22.0	20.0-2	0.505		
97112109	97082524	Lab Growth	A/E	60 day		A15	17.5	20.0-3	0.516	6.488	
97112110	97082525	Lab Growth	A/E	60 day		A16	20.4	30.0-1	0.567		
97112111	97082526	Lab Growth	A/E	60 day		A17	19.8	30.0-2	0.614		Assay date
97112112	97082527	Lab Growth	NQSE	60 day		A18	20.9	30.0-3	0.587	4.002	12/12/98
97112113	97082528	Lab Growth	NQSE	60 day		A19	18.8				
97112114	97082529	Lab Growth	NQSE	60 day		A20	21.5				
97112115	97082530	Lab Growth	NQSE	60 day		A21	21.1				
97112116	97082531	Lab Growth	HCED	60 day		A22	22.3				
97112117	97082532	Lab Growth	HCED	60 day		A23	23.4				
97112118	97082533	Lab Growth	HCED	60 day		A24	22.5				
97112119	97082534	Lab Growth	HCED	60 day	971121	A01	21.4	2.0-1	0.274		0.999
								2.0-2	0.272		
								2.0-3	0.268	1.125	

µsome #	Sample #	Study	Trtmnt	Time	Plate #	Prot. Sample #	mg Prot. /ml

Protein Standard Curve

Prot. Std. Conc.#	Prot.Std OD value	OD %CV (<20%)	Corr. Coeff. (>0.95)
4.0-1	0.298		
4.0-2	0.301		
4.0-3	0.3	0.509	
8.0-1	0.363		
8.0-2	0.356		
8.0-3	0.354	1.322	
16.0-1	0.442		
16.0-2	0.443		
16.0-3	0.47	3.517	
20.0-1	0.494		
20.0-2	0.493		
20.0-3	0.514	2.367	
30.0-1	0.608		
30.0-2	0.624		**Assay date**
30.0-3	0.593	2.549	**12/12/98**

Juvenile Salmon - Biomarker Studies

Analyses of Cytochrome P4501A [measured as aryl hydrocarbon hydroxylase(AHH) Activity]

Table 2 Notes

Method Blank - AHH Assay

The numbers under columns Microsome # (column abbr. µsome #), AHH # and Sample # are internal lab use numbers and for identification only. Column Final Liver Comp# is the official number assigned to each composited sample.

The AHH Assay Date column is the day sample set was run. The column AHH Set Blk (µsome #) is the sample run as the blank for each set.

Substrate blank is reaction mixture without substrate (^{14}C-Benzo[a]Pyrene) added. Boiled blank is reaction mixture with an aliquot of boiled microsome sample. Both blank sets run as duplicates (i.e. DPM1 and DPM2). All 4 blanks are then averaged to give AHH Assay Set Blk Avg DPM .

AHH Assay Date	usome #	AHH #	Sample #	Study	Trtmnt	Time	AHH Set Blk (µsome#)	Substrate Blk (DPM1)	Substrate Blk (DPM2)	Boiled Blk (DPM1)	Boiled Blk (DPM2)
1/20/98	97103001	1/20/98-1	970710DA001	Biomarker	none	0	97103004	55	58	47	54
	97103002	1/20/98-2	970710DA002	Biomarker	none	0					
	97103003	1/20/98-3	970710DA003	Biomarker	none	0					
	97103004	1/20/98-4	970715DA01	Biomarker	A/E	6 day					
	97103005	1/20/98-5	970715DA02	Biomarker	A/E	6 day					
	97103006	1/20/98-6	970715DA03	Biomarker	A/E	6 day					
	97103007	1/20/98-7	970729DA43	Biomarker	A/E	20 day					
	97103008	1/20/98-8	970729DA44	Biomarker	A/E	20 day					
	97103009	1/20/98-9	970729DA45	Biomarker	A/E	20 day					
	97103010	1/20/98-10	970813DA100	Biomarker	A/E	35 day					
	97103011	1/20/98-11	970813DA101	Biomarker	A/E	35 day					
	97103012	1/20/98-12	970813DA102	Biomarker	A/E	35 day					
	97103101	1/20/98-13	970715DA10	Biomarker	HWSE-P	6 day					
	97103102	1/20/98-14	970715DA11	Biomarker	HWSE-P	6 day					
	97103103	1/20/98-15	970715DA12	Biomarker	HWSE-P	6 day					
	97103104	1/20/98-16	970729DA52	Biomarker	HWSE-P	20 day					
	97103105	1/20/98-17	970729DA53	Biomarker	HWSE-P	20 day					
	97103106	1/20/98-18	970729DA54	Biomarker	HWSE-P	20 day					
	97103107	1/20/98-19	970903DA106	Biomarker	HWSE-P	56 day					
	97103108	1/20/98-20	970903DA107	Biomarker	HWSE-P	56 day					
	97103109	1/20/98-21	970903DA108	Biomarker	HWSE-P	56 day					
	97103110	1/20/98-22	970715DA13	Biomarker	HCBD	6 day					
	97103111	1/20/98-23	970715DA14	Biomarker	HCBD	6 day					
	97103112	1/20/98-24	970715DA15	Biomarker	HCBD	6 day					
	97110301	1/20/98-25	970729DA58	Biomarker	HCBD	20 day					
	97110302	1/20/98-26	970729DA59	Biomarker	HCBD	20 day					
	97110303	1/20/98-27	970729DA60	Biomarker	HCBD	20 day					
	97110304	1/20/98-28	970903DA118	Biomarker	HCBD	56 day					
	97110305	1/20/98-29	970903DA119	Biomarker	HCBD	56 day					
	97110306	1/20/98-30	970903DA120	Biomarker	HCBD	56 day					
	97110307	1/20/98-31	970715DA07	Biomarker	HWSE-M	6 day					
2/2/98	97110308	2/2/98-1	970715DA08	Biomarker	HWSE-M	6 day	97110308	59	62	74	75
	97110309	2/2/98-2	970715DA09	Biomarker	HWSE-M	6 day					

AHH Assay Set Blk

Avg DPM 54

AHH Assay Date	usome #	AHH #	Sample #	Study	Trtmnt	Time	AHH Set Blk (µsome#)	Substrate Blk (DPM1)	Substrate Blk (DPM2)	Boiled Blk (DPM1)	Boiled Blk (DPM2)
	97110310	2/2/98-3	970729DA55	Biomarker	HWSE-M	20 day					
	97110311	2/2/98-4	970729DA56	Biomarker	HWSE-M	20 day					
	97110312	2/2/98-5	970729DA57	Biomarker	HWSE-M	20 day					
	97110601	2/2/98-6	970811DA85	Biomarker	HWSE-M	33 day					
	97110602	2/2/98-7	970811DA86	Biomarker	HWSE-M	33 day					
	97110603	2/2/98-8	970811DA87	Biomarker	HWSE-M	33 day					
	97110604	2/2/98-9	970715DA04	Biomarker	NQSE	6 day					
	97110605	2/2/98-10	970715DA05	Biomarker	NQSE	6 day					
	97110606	2/2/98-11	970715DA06	Biomarker	NQSE	6 day					
	97110607	2/2/98-12	970729DA46	Biomarker	NQSE	20 day					
	97110608	2/2/98-13	970729DA47	Biomarker	NQSE	20 day					
	97110609	2/2/98-14	970729DA48	Biomarker	NQSE	20 day					
	97110610	2/2/98-15	970811DA91	Biomarker	NQSE	33 day					
	97110611	2/2/98-16	970811DA92	Biomarker	NQSE	33 day					
	97110612	2/2/98-17	970811DA93	Biomarker	NQSE	33 day					
	97111001	2/2/98-18	970715DA16	Biomarker	PAHs	6 day					
	97111002	2/2/98-19	970715DA17	Biomarker	PAHs	6 day					
	97111003	2/2/98-2	970715DA18	Biomarker	PAHs	6 day					
	97111004	2/2/98-21	970729DA49	Biomarker	PAHs	20 day					
	97111005	2/2/98-22	970729DA50	Biomarker	PAHs	20 day					
	97111006	2/2/98-23	970729DA51	Biomarker	PAHs	20 day					
	97111007	2/2/98-24	970909DA121	Biomarker	PAHs	62 day					
	97111008	2/2/98-25	970909DA122	Biomarker	PAHs	62 day					
	97111009	2/2/98-26	970909DA123	Biomarker	PAHs	62 day					
	97111010	2/2/98-27	970715DA19	Biomarker	PCBs	6 day					
	97111011	2/2/98-28	970715DA20	Biomarker	PCBs	6 day					
	97111012	2/2/98-29	970715DA21	Biomarker	PCBs	6 day					
	97111013	2/2/98-30	970729DA61	Biomarker	PCBs	20 day					
	97111014	2/2/98-31	970729DA62	Biomarker	PCBs	20 day					
2/3/98	97111015	2/3/98-1	970729DA63	Biomarker	PCBs	20 day	97110308	61	69	60	53
	97111016	2/3/98-2	970909DA124	Biomarker	PCBs	62 day					
	97111017	2/3/98-3	970909DA125	Biomarker	PCBs	62 day					
	97111018	2/3/98-4	970909DA126	Biomarker	PCBs	62 day					

AHH Assay Set Blk

Avg DPM 68

AHH Assay Date	usome #	AHH #	Sample #	Study	Trtmnt	Time	AHH Set Blk (µsome#)	Substrate Blk (DPM1)	Substrate Blk (DPM2)	Boiled Blk (DPM1)	Boiled Blk (DPM2)
	97112001	2/3/98-5	97062601	Lab Growth	none	0					
	97112002	2/3/98-6	97062602	Lab Growth	none	0					
	97112003	2/3/98-7	97062603	Lab Growth	none	0					
	97112004	2/3/98-8	97082507	Lab Growth	PCBs	60 day					
	97112005	2/3/98-9	97082508	Lab Growth	PCBs	60 day					
	97112006	2/3/98-10	97082509	Lab Growth	PCBs	60 day					
	97112007	2/3/98-11	97082510	Lab Growth	PCBs	60 day					
	97112008	2/3/98-12	97082511	Lab Growth	HWSE-M	60 day					
	97112009	2/3/98-13	97082512	Lab Growth	HWSE-M	60 day					
	97112010	2/3/98-14	97082513	Lab Growth	HWSE-M	60 day					
	97112011	2/3/98-15	97082514	Lab Growth	HWSE-M	60 day					
	97112012	2/3/98-16	97082515	Lab Growth	HWSE-P	60 day					
	97112101	2/3/98-17	97082516	Lab Growth	HWSE-P	60 day					
	97112102	2/3/98-18	97082517	Lab Growth	HWSE-P	60 day					
	97112103	2/3/98-19	97082518	Lab Growth	HWSE-P	60 day					
	97112104	2/3/98-2	97082519	Lab Growth	PAHs	60 day					
	97112105	2/3/98-21	97082520	Lab Growth	PAHs	60 day					
	97112106	2/3/98-22	97082521	Lab Growth	PAHs	60 day					
	97112107	2/3/98-23	97082522	Lab Growth	PAHs	60 day					
	97112108	2/3/98-24	97082523	Lab Growth	A/E	60 day					
	97112109	2/3/98-25	97082524	Lab Growth	A/E	60 day					
	97112110	2/3/98-26	97082525	Lab Growth	A/E	60 day					
	97112111	2/3/98-27	97082526	Lab Growth	A/E	60 day					
	97112112	2/3/98-28	97082527	Lab Growth	NQSE	60 day					
	97112113	2/3/98-29	97082528	Lab Growth	NQSE	60 day					
	97112114	2/3/98-30	97082529	Lab Growth	NQSE	60 day					
	97112115	2/3/98-31	97082530	Lab Growth	NQSE	60 day					
	97112116	2/3/98-32	97082531	Lab Growth	HCBD	60 day					
	97112117	2/3/98-33	97082532	Lab Growth	HCBD	60 day					
	97112118	2/3/98-34	97082533	Lab Growth	HCBD	60 day					
	97112119	2/3/98-35	97082534	Lab Growth	HCBD	60 day					

AHH Assay Set Blk	
Avg DPM	61

Juvenile Salmon Injury

Analyses of Cytochrome P4501A [measured as aryl hydrocarbon hydroxylase(AHH) Activity]

Table 3 Notes

Performance Evaluation Final - AHH Activity

Microsome # (column abbr. µsome #), AHH # and Sample # are internal lab use numbers and for identification only. Column Final Liver Comp# is the official number assigned to each composited sample.

The AHH Assay Date column is the day sample set was run. The AHH Set Blk (µsome #) is the sample run as the blank for each set.

Samples are run in triplicate. The percent coefficient of variation (%CV of DPM column) is the standard deviation (value reported in column DPM SD) of each triplicate (reported in columns :AHH DPM1, AHH DPM2, AHH DPM3) divided by mean of each triplicate (column AHH DPM Avg) multiplied by 100.

Triplicate sample outlier indicated by •, was not used in final calculation to meet criteria of %CV < 30%.

The column Avg AHH minus set Blk, is AHH DPM Avg , minus the value calculated in **Table 2** (AHH set Blk) for each set.

Final AHH Activity is normalized for total microsomal protein i.e. "Avg AHH minus set Blk" divided by "mg prot/ ml" (from **Table 1**).

Final units for AHH activity are picomoles BaP metabolized per minute per mg microsomal protein.

Table 3 : Performance Evaluation Final - Aryl hydrocarbon hydroxlase (AHH) Activity Calculations Hylebos/NRDA Juvenile Salmon Biomarker Response Studies Page 1 of 3

Assay Date	useome #	AHH #	Sample #	Study	Trtmnt	Time	AHH Set Blk	mg prot. /ml	AHH DPM1	AHH DPM2	AHH DPM3	AHH DPM Avg	DPM SD	%CV of DPM (<30%)	Avg AHH minus Set Blk	Final AHH Activity
1/20/98	97103001	1/20/98-1	970710DA001	Biomarker	none	0	54	14.4	239	227	228	231	7	3	177	71
	97103002	1/20/98-2	970710DA002	Biomarker	none	0		16.4	235	239	175	216	36	17	162	67
	97103003	1/20/98-3	970710DA003	Biomarker	none	0		17.9	212	277	271	253	36	14	199	76
	97103004	1/20/98-4	970715DA01	Biomarker	A/E	6 day		19.8	494	558	511	521	33	6	467	160
	97103005	1/20/98-5	970715DA02	Biomarker	A/E	6 day		16.4	402	385	433	407	24	6	353	146
	97103006	1/20/98-6	970715DA03	Biomarker	A/E	6 day		16.6	430	414	437	427	12	3	373	153
	97103007	1/20/98-7	970729DA43	Biomarker	A/E	20 day		19.7	455	462	470	462	8	2	408	141
	97103008	1/20/98-8	970729DA44	Biomarker	A/E	20 day		18.0	456	453	429	447	16	3	393	148
	97103009	1/20/98-9	970729DA45	Biomarker	A/E	20 day		19.1	390	391	389	390	1	0.3	336	120
	97103010	1/20/98-10	970813DA100	Biomarker	A/E	35 day		15.4	173	177	193	181	11	6	127	56
	97103011	1/20/98-11	970813DA101	Biomarker	A/E	35 day		16.6	204	200	147	184	32	17	130	53
	97103012	1/20/98-12	970813DA102	Biomarker	A/E	35 day		16.2	221	•73	212	217	6	3	163	68
	97103101	1/20/98-13	970715DA10	Biomarker	HWSE-P	6 day		17.4	1890	1661	1537	1696	179	11	1642	642
	97103102	1/20/98-14	970715DA11	Biomarker	HWSE-P	6 day		20.0	1598	1359	•702	1479	169	11	1425	485
	97103103	1/20/98-15	970715DA12	Biomarker	HWSE-P	6 day		17.3	•121	2031	2061	2046	21	1	1992	783
	97103104	1/20/98-16	970729DA52	Biomarker	HWSE-P	20 day		18.4	920	907	845	891	40	4	837	309
	97103105	1/20/98-17	970729DA53	Biomarker	HWSE-P	20 day		16.9	720	677	698	698	22	3	644	259
	97103106	1/20/98-18	970729DA54	Biomarker	HWSE-P	20 day		17.7	667	716	688	690	25	4	636	245
	97103107	1/20/98-19	970903DA106	Biomarker	HWSE-P	56 day		21.1	317	326	338	327	11	3	273	88
	97103108	1/20/98-20	970903DA107	Biomarker	HWSE-P	56 day		19.5	178	199	179	185	12	6	131	46
	97103109	1/20/98-21	970903DA108	Biomarker	HWSE-P	56 day		21.2	262	274	237	258	19	7	204	65
	97103110	1/20/98-22	970715DA13	Biomarker	HCBD	6 day		14.8	301	284	312	299	14	5	245	113
	97103111	1/20/98-23	970715DA14	Biomarker	HCBD	6 day		18.0	382	400	388	390	9	2	336	127
	97103112	1/20/98-24	970715DA15	Biomarker	HCBD	6 day		15.4	302	269	298	290	18	6	236	104
	97110301	1/20/98-25	970729DA58	Biomarker	HCBD	20 day		19.5	568	545	540	551	15	3	497	173
	97110302	1/20/98-26	970729DA59	Biomarker	HCBD	20 day		20.3	644	547	654	615	59	10	561	188
	97110303	1/20/98-27	970729DA60	Biomarker	HCBD	20 day		19.6	613	674	639	642	31	5	588	204
	97110304	1/20/98-28	970903DA116	Biomarker	HCBD	56 day		19.3	261	254	269	261	8	3	207	73
	97110305	1/20/98-29	970903DA119	Biomarker	HCBD	56 day		18.8	213	267	267	249	31	13	195	71
	97110306	1/20/98-30	970903DA120	Biomarker	HCBD	56 day		16.6	193	183	148	175	24	14	121	49
	97110307	1/20/98-31	970715DA07	Biomarker	HWSE-M	6 day		17.5	2836	3242	3220	3099	228	7	3045	1184
2/2/98	97110308	2/2/98-1	970715DA08	Biomarker	HWSE-M	6 day	68	17.1	3022	2907	3083	3004	89	3	2936	1168
	97110309	2/2/98-2	970715DA09	Biomarker	HWSE-M	6 day		15.0	2373	2162	2415	2317	136	6	2249	1020
	97110310	2/2/98-3	970729DA55	Biomarker	HWSE-M	20 day		17.4	989	981	1004	991	12	1	923	361

Table 3 : Performance Evaluation Final - Aryl hydrocarbon hydroxlase (AHH) Activity Calculations Hylebos/NRDA Juvenile Salmon Biomarker Response Studies

Assay Date	usome #	AHH #	Sample #	Study	Trtmnt	Time	AHH Set Blk	mg prot. /ml	AHH DPM1	AHH DPM2	AHH DPM3	AHH DPM Avg	DPM SD	%CV of DPM (<30%)	Avg AHH minus Set Blk	Final AHH Activity
	97110311	2/2/98-4	970729DA56	Biomarker	HWSE-M	20 day		11.1	349	352	352	351	2	0.5	283	173
	97110312	2/2/98-5	970729DA57	Biomarker	HWSE-M	20 day		17.5	1018	937	857	937	81	9	869	338
	97110601	2/2/98-6	970811DA85	Biomarker	HWSE-M	33 day		20.5	418	428	462	436	23	5	368	122
	97110602	2/2/98-7	970811DA86	Biomarker	HWSE-M	33 day		20.4	397	451	440	429	29	7	361	120
	97110603	2/2/98-8	970811DA87	Biomarker	HWSE-M	33 day		21.7	408	407	401	405	4	1	337	106
	97110604	2/2/98-9	970715DA04	Biomarker	NQSE	6 day		19.5	865	940	1005	937	70	7	869	303
	97110605	2/2/98-10	970715DA05	Biomarker	NQSE	6 day		16.4	900	909	914	908	7	1	840	348
	97110606	2/2/98-11	970715DA06	Biomarker	NQSE	6 day		18.6	1071	1008	995	1025	41	4	957	350
	97110607	2/2/98-12	970729DA46	Biomarker	NQSE	20 day		19.1	454	474	467	465	10	2	397	141
	97110608	2/2/98-13	970729DA47	Biomarker	NQSE	20 day		16.4	443	449	458	450	8	2	382	158
	97110609	2/2/98-14	970729DA48	Biomarker	NQSE	20 day		18.5	431	425	444	433	10	2	365	134
	97110610	2/2/98-15	970811DA91	Biomarker	NQSE	33 day		21.6	452	442	453	449	6	1	381	120
	97110611	2/2/98-16	970811DA92	Biomarker	NQSE	33 day		19.8	395	428	401	408	18	4	340	117
	97110612	2/2/98-17	970811DA93	Biomarker	NQSE	33 day		19.7	345	297	346	329	28	9	261	90
	97111001	2/2/98-18	970715DA16	Biomarker	PAHs	6 day		18.6	2588	2520	2602	2570	44	2	2502	915
	97111002	2/2/98-19	970715DA17	Biomarker	PAHs	6 day		20.6	2432	2387	2454	2424	34	1	2356	778
	97111003	2/2/98-2	970715DA18	Biomarker	PAHs	6 day		20.9	2559	2559	2486	2535	42	2	2467	803
	97111004	2/2/98-21	970729DA49	Biomarker	PAHs	20 day		21.6	707	672	678	686	19	3	618	195
	97111005	2/2/98-22	970729DA50	Biomarker	PAHs	20 day		18.4	626	610	598	611	15	2	543	201
	97111006	2/2/98-23	970729DA51	Biomarker	PAHs	20 day		20.0	643	655	666	655	13	2	587	200
	97111007	2/2/98-24	970909DA121	Biomarker	PAHs	62 day		18.5	256	282	269	269	13	5	201	74
	97111008	2/2/98-25	970909DA122	Biomarker	PAHs	62 day		19.2	301	293	310	301	9	3	233	83
	97111009	2/2/98-26	970909DA123	Biomarker	PAHs	62 day		18.4	321	317	302	313	10	3	245	91
	97111010	2/2/98-27	970715DA19	Biomarker	PCBs	6 day		18.1	2354	2416	2329	2366	45	2	2298	864
	97111011	2/2/98-28	970715DA20	Biomarker	PCBs	6 day		22.6	3091	3139	3091	3107	28	1	3039	915
	97111012	2/2/98-29	970715DA21	Biomarker	PCBs	6 day		18.7	2421	2310	2375	2369	56	2	2301	837
	97111013	2/2/98-30	970729DA61	Biomarker	PCBs	20 day		21.4	3483	3279	3218	3327	139	4	3259	1036
	97111014	2/2/98-31	970729DA62	Biomarker	PCBs	20 day		21.9	3444	2624	3436	3168	471	15	3100	963
2/3/98	97111015	2/3/98-1	970729DA63	Biomarker	PCBs	20 day	61	24.4	3693	3352	3355	3467	196	6	3406	950
	97111016	2/3/98-2	970909DA124	Biomarker	PCBs	62 day		22.2	857	921	896	891	32	4	830	254
	97111017	2/3/98-3	970909DA125	Biomarker	PCBs	62 day		22.8	917	958	951	942	22	2	881	263
	97111018	2/3/98-4	970909DA126	Biomarker	PCBs	62 day		22.3	809	943	981	911	90	10	850	259
	97112001	2/3/98-5	97062801	Lab Growth	none	0		21.6	407	382	389	393	13	3	332	104
	97112002	2/3/98-6	97062802	Lab Growth	none	0		20.5	291	307	301	300	8	3	239	79

Assay Date	usome #	AHH #	Sample #	Study	Trtmnt	Time	AHH Set Blk	mg prot. /ml	AHH DPM1	AHH DPM2	AHH DPM3	AHH DPM Avg	DPM SD	%CV of DPM (<30%)	Avg AHH minus Set Blk	Final AHH Activity
	97112003	2/3/98-7	97062603	Lab Growth	none	0		24.2	441	462	355	419	57	14	358	101
	97112004	2/3/98-8	97082507	Lab Growth	PCBs	60 day		25.4	1366	1280	1330	1325	43	3	1264	339
	97112005	2/3/98-9	97082508	Lab Growth	PCBs	60 day		23.9	1574	1408	1526	1503	85	6	1442	410
	97112006	2/3/98-10	97082509	Lab Growth	PCBs	60 day		24.9	1300	1279	1225	1268	39	3	1207	330
	97112007	2/3/98-11	97082510	Lab Growth	PCBs	60 day		22.8	923	959	959	947	21	2	886	264
	97112008	2/3/98-12	97082511	Lab Growth	HWSE-M	60 day		22.7	364	354	376	365	11	3	304	91
	97112009	2/3/98-13	97082512	Lab Growth	HWSE-M	60 day		21.6	395	390	361	382	18	5	321	101
	97112010	2/3/98-14	97082513	Lab Growth	HWSE-M	60 day		20.8	372	339	405	372	33	9	311	102
	97112011	2/3/98-15	97082514	Lab Growth	HWSE-M	60 day		23.5	372	356	382	370	13	4	309	89
	97112012	2/3/98-16	97082515	Lab Growth	HWSE-P	60 day		21.5	294	248	289	277	25	9	216	68
	97112101	2/3/98-17	97082516	Lab Growth	HWSE-P	60 day		20.3	309	262	284	285	24	8	224	75
	97112102	2/3/98-18	97082517	Lab Growth	HWSE-P	60 day		21.9	352	405	354	370	30	8	309	96
	97112103	2/3/98-19	97082518	Lab Growth	HWSE-P	60 day		23.8	350	378	383	370	18	5	309	88
	97112104	2/3/98-2	97082519	Lab Growth	PAHs	60 day		22.7	372	391	353	372	19	5	311	93
	97112105	2/3/98-21	97082520	Lab Growth	PAHs	60 day		19.7	253	303	•455	278	35	13	217	75
	97112106	2/3/98-22	97082521	Lab Growth	PAHs	60 day		20.8	295	462	464	407	97	24	346	113
	97112107	2/3/98-23	97082522	Lab Growth	PAHs	60 day		22.2	386	383	350	373	20	5	312	96
	97112108	2/3/98-24	97082523	Lab Growth	A/E	60 day		22.0	270	375	342	329	54	16	268	83
	97112109	2/3/98-25	97082524	Lab Growth	A/E	60 day		17.5	217	262	291	257	37	15	196	76
	97112110	2/3/98-26	97082525	Lab Growth	A/E	60 day		20.4	256	335	309	300	40	13	239	80
	97112111	2/3/98-27	97082526	Lab Growth	A/E	60 day		19.8	298	260	273	277	19	7	216	74
	97112112	2/3/98-28	97082527	Lab Growth	NQSE	60 day		20.9	269	313	294	292	22	8	231	75
	97112113	2/3/98-29	97082528	Lab Growth	NQSE	60 day		18.8	280	242	200	241	40	17	180	65
	97112114	2/3/98-30	97082529	Lab Growth	NQSE	60 day		21.5	259	278	295	277	18	6	216	68
	97112115	2/3/98-31	97082530	Lab Growth	NQSE	60 day		21.1	320	313	291	308	15	5	247	80
	97112116	2/3/98-32	97082531	Lab Growth	HCBD	60 day		22.3	243	252	286	260	23	9	199	61
	97112117	2/3/98-33	97082532	Lab Growth	HCBD	60 day		23.4	233	221	242	232	11	5	171	50
	97112118	2/3/98-34	97082533	Lab Growth	HCBD	60 day		22.5	372	383	370	375	7	2	314	95
	97112119	2/3/98-35	97082534	Lab Growth	HCBD	60 day		21.4	347	370	422	380	38	10	319	101

ANOVA Output: CYP1A results of biomarker study samples (6,20,33,35,56, and 62 d post exposure) and growth study samples (60 d post exposure).

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treatment	6	2738423.619	456403.937	2.53E2	.0001
Time	6	3451656.953	575309.492	3.19E2	.0001
Treatment * Time	15	2117392.056	141159.470	78.180	.0001
Residual	68	122778.500	1805.566		

Dependent: Final AHH

Means Table
Effect: Treatment * Time
Dependent: Final AHH

	Count	Mean	Std. Dev.	Std. Error
none, 0 day	6	83.000	15.684	6.403
A/E, 06 days	3	153.000	7.000	4.041
A/E, 20 days	3	136.333	14.572	8.413
A/E, 35 days	3	59.000	7.937	4.583
A/E, 60 days	4	78.250	4.031	2.016
HWSE-P, 06 days	3	636.667	149.072	86.067
HWSE-P, 20 days	3	271.000	33.645	19.425
HWSE-P, 56 days	3	66.333	21.032	12.143
HWSE-P, 60 days	4	81.750	12.606	6.303
HCBD, 06 days	3	114.667	11.590	6.692
HCBD, 20 days	3	166.333	15.503	8.950
HCBD, 56 days	3	64.333	13.317	7.688
HCBD, 60 days	4	76.750	25.065	12.532
HWSE-M, 06 days	3	1124.000	90.421	52.205
HWSE-M, 20 days	3	290.667	102.549	59.207
HWSE-M, 33 days	3	116.000	8.718	5.033
HWSE-M, 60 days	4	95.750	6.702	3.351
NQSE, 06 days	3	333.667	26.577	15.344
NQSE, 20 days	3	144.333	12.342	7.126
NQSE, 33 days	3	109.000	16.523	9.539
NQSE, 60 days	4	72.000	6.782	3.391
PAHs, 06 days	3	832.000	72.959	42.123
PAHs, 20 days	3	198.667	3.215	1.856
PAHs, 62 days	3	82.667	8.505	4.910
PAHs, 60 days	4	94.250	15.564	7.782
PCBs, 06 days	3	872.000	39.611	22.869
PCBs, 20 days	3	983.000	46.357	26.764
PCBs, 62 days	3	258.667	4.509	2.603
PCBs, 60 days	4	335.750	59.735	29.867

from both biomarker and growth studies

ANOVA Output: Treatment Effects (SuperANOVA, Abacus Concepts Inc., Berkeley, CA).
CYP1A activity (AHH) at 6 d post exposure.

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treatment	6	2722362.571	453727.095	83.187	.0001
Residual	14	76360.000	5454.286		

Dependent: Final AHH

Means Table
Effect: Treatment
Dependent: Final AHH

	Count	Mean	Std. Dev.	Std. Error
A/E	3	153.000	7.000	4.041
HWSE-P	3	636.667	149.072	86.067
HCBD	3	114.667	11.590	6.692
HWSE-M	3	1124.000	90.421	52.205
NCSE	3	333.667	26.577	15.344
PAHs	3	832.000	72.959	42.123
PCBs	3	872.000	39.611	22.869

Dunnett Two-Tailed
Effect: Treatment
Dependent: Final AHH
Significance level: .05

	Vs.	Diff.	Crit. diff.	
A/E	HCBD	-38.333	175.475	
	NCSE	180.667	175.475	S
	HWSE-P	483.667	175.475	S
	PAHs	679.000	175.475	S
	PCBs	719.000	175.475	S
	HWSE-M	971.000	175.475	S

S = Significantly different at this level.

ANOVA Output: Treatment Effects (SuperANOVA, Abacus Concepts Inc., Berkeley, CA).
CYP1A activity (AHH) at 20 d post exposure.

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treatment	6	1618113.619	269685.603	130.982	.0001
Residual	14	28825.333	2058.952		

Dependent: Final AHH

Means Table
Effect: Treatment
Dependent: Final AHH

	Count	Mean	Std. Dev.	Std. Error
A/E	3	136.333	14.572	8.413
HWSE-P	3	271.000	33.645	19.425
HCBD	3	188.333	15.503	8.950
HWSE-M	3	290.667	102.549	59.207
NQSE	3	144.333	12.342	7.126
PAHs	3	198.667	3.215	1.856
PCBs	3	983.000	46.357	26.764

Dunnett Two-Tailed
Effect: Treatment
Dependent: Final AHH
Significance level: .05

	Vs.	Diff.	Crit. diff.	
A/E	NQSE	8.000	107.813	
	HCBD	52.000	107.813	
	PAHs	62.333	107.813	
	HWSE-P	134.667	107.813	S
	HWSE-M	154.333	107.813	S
	PCBs	846.667	107.813	S

S = Significantly different at this level.

ANOVA Output: Treatment Effects (SuperANOVA, Abacus Concepts Inc., Berkeley, CA).
CYP1A activity (AHH) at 60 d post exposure.

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treatment	6	220702.214	36783.702	54.728	.0001
Residual	21	14114.500	672.119		

Dependent: Final AHH

Means Table
Effect: Treatment
Dependent: Final AHH

	Count	Mean	Std. Dev.	Std. Error
A/E	4	78.250	4.031	2.016
HWSE-P	4	81.750	12.606	6.303
HCBD	4	76.750	25.065	12.532
HWSE-M	4	95.750	6.702	3.351
NQSE	4	72.000	6.782	3.391
PAHs	4	94.250	15.564	7.782
PCBs	4	335.750	59.735	29.867

Dunnett Two-Tailed
Effect: Treatment
Dependent: Final AHH
Significance level: .05

	Vs.	Diff.	Crit. diff.	
A/E	NQSE	-6.250	51.144	
	HCBD	-1.500	51.144	
	HWSE-P	3.500	51.144	
	PAHs	16.000	51.144	
	HWSE-M	17.500	51.144	
	PCBs	257.500	51.144	S

S = Significantly different at this level.

Hylebos Fish Injury Study - Round II, Part 3
Individual Data and Quality Assurance Results
CASE NARRATIVE

Juvenile Salmon Biomarker Response Studies

PCBs and Pesticides

Semi-volatile Organics

Calibrations
The calibration data used to quantitate the analytes (Tables 1J,1K, and 1L) met the initial and continuing calibration criteria detailed in the "Commencement Bay Quality Assurance Plan, 12/95" (QAP). The only exception exception was for the standard curve correlation (r) for p,p'-DDT in set H506 (0.9857). However, p,p'-DDT was not detected in the sample set.

Method Blank Analysis
The criteria in the QAP for method blanks (Tables 1E, 1F) were met (no more than 4 analytes to exceed 3 X MDL listed in Table 1M of this report).

Surrogate Recoveries
Surrogate recoveries for sample analyzed for PCBs, DDTs, pesticides, and hexachlorobutadiene (Tables 1A, 1D) were within the guidelines detailed in the QA Plan (50 - 125% recovery).

Reference Material Analyses
An aliquot of NIST tissue SRM 1974a was analyzed with each of the sample sets, and the results (Tables 1E, 1F) met the criteria in the QA plan (>70% of the concentrations for the certified analytes that were present in the NIST SRM 1974a in concentrations greater thaaaan 10 times the MDL were within 35% of either of the NIST certified value ± 95% confidence interval. Some concentrations for p,p'-DDE, p,p'-DDT and PCB congener 180 were below the criteria but were considerably lower than 10x MDL. Noncertified values for the other analytes in the SRM are also shown in the Tables.

Sample Duplicates/Replicates
The RSDs for the concentrations of analytes in the replicate analyses of the samples were less than 50% (Tables 1H, 1I), meeting the criteria in the QAP, 12/95, Table 6.2.

Reanalyses
There is no plan to reanalyze any samples.

1997 Hylebos Salmon Growth Study

Analyses for chemicals in tissues

Data for these analyses are provided as follows:

Table 1 reports concentrations (in ng/g, wet weight) of chlorinated hydrocarbons.

Table 1A provides sample information such as sample weight, dry weight, field sample numbers (as provided by the field sampling group), and surrogate recoveries for field samples analyzed as part of this project.
Table 1B provides concentrations of pesticides in field samples analyzed as part of this project.
Table 1C provides concentrations of PCBs in field samples analyzed as part of this project.
Table 1D provides sample information for QA samples (method blanks and SRMs) analyzed as part of this project.
Table 1E provides concentrations of pesticides in QA samples (method blanks and SRMs) analyzed as part of this project.
Table 1F provides concentrations of PCBs in QA samples (method blanks and SRMs) analyzed as part of this project.
Table 1G provides sample information for QA samples (replicates of field samples) analyzed as part of this project.
Table 1H provides concentrations of pesticide in QA samples (replicates of field samples) analyzed as part of this project.
Table 1I provides concentrations of PCBs in QA samples (replicates of field samples) analyzed as part of this project.
Table 1J provides continuing calibration data for pesticides in standards analyzed with each set as part of this project.
Table 1K provides continuing calibration data for PCBs in standards analyzed with each set as part of this project.
Table 1L provides correlation data for the standard calibration curves analyzed with each set as part of this project.
Table 1M provides method detection limits for chlorinated hydrocarbons analyzed as part of this project.

1997 Hylebos Salmon Growth Study

Table 1
Analyses for Chlorinated Hydrocarbons in tissues
Notes

The concentrations of analytes were calculated using 4,4'-dibromooctafluorobiphenyl as the surrogate standard.

The "less than" symbol (<) indicates that the analyte was not detected in concentrations above the stated value.

"NR" denotes that the indicated analyte was not reported; the circumstances are explained in the footnotes.

Results were determined using gas chromatography (GC) with electron capture detection (ECD), except where noted for analytes exceeding the ECD calibration range.

The percent recovery of the surrogate standard was calculated using tetrachloro-*o*-xylene to correct for the fraction of the total extract used for the HPLC cleanup step, with tetrachloro-*m*-xylene as the internal standard.

Concentrations are reported as if two figures are significant.

The concentration reported for "PCBs (Est. Total)" is an estimate of the total PCBs obtained by taking the sum of the concentrations of the 17 congeners reported in Table 1C, and multiplying by 2.

The sample weight used to calculate analyte concentrations for method blanks is the mean sample weight of all field samples in the same sample set.

Set # and Sample # designations are intended for internal lab use and identification only. Field sample numbers, as provided by the field sampling group, are included to aid in identifying individual specimens used to make up sample composites.

Table 1A-p1: Sample information for tissues analyzed for chlorinated hydrocarbons as part of the 1997 Hylebos Salmon Exposure/Growth Study.

Set #	Sample#	Field Sample #s		Lipid (%)	Sample Wt. (g)	DOB Recovery (%)
Exposure Group CARRIER						
Tissue - liver						
H506	110-495	970715DA22L			0.42 §	96
H506	110-496	970715DA23L			0.49 §	96
H506	110-497	970729DA67L			0.60 §	93
H507	110-509	970729DA68L			0.47 §	96
H507	110-510	97082553L			1.71	94
H508	110-523	97082554L			2.14	102
Tissue - whole body						
H511	110-568	970715DA22B		1.9%	4.82	97
H510	110-554	970715DA23B		1.7%	5.25	91
H510	110-555	970729DA67B		3.2%	4.90	92
H512	110-578	970729DA68B		2.9%	4.70	100
H512	110-579	97082553B		6.1%	4.85	99
H513	110-592	97082554B		6.4%	5.22	58
Exposure Group HCBD						
Tissue - liver						
H509	110-537	970715DA34L			0.38 §	92
H509	110-538	970715DA35L			0.49 §	90
H509	110-539	970729DA76L			0.47 §	89
H509	110-540	970729DA77L			0.52 §	95
H509	110-541	97082559L			2.93	93
H509	110-542	97082560L			1.81	92
H515	110-623	97082561L			2.30	94
H515	110-624	97082562L			2.19	96
Tissue - whole body						
H509	110-543	970715DA34B		2.8%	5.03	97
H509	110-544	970715DA35B		2.1%	5.18	95
H509	110-545	970729DA76B		3.1%	4.79	95
H509	110-546	970729DA77B		2.7%	5.25	93
H510	110-551	97082559B	original	5.3%	5.12	99
H510	110-553	97082559B	duplicate	5.4%	4.96	98
H510	110-552	97082560B		5.5%	5.35	95
Exposure Group HWSE-M						
Tissue - liver						
H506	110-501	970715DA31L			0.52 §	92
H506	110-502	970715DA32L			0.47 §	89
H507	110-514	970729DA79L			0.71 §	93
H507	110-515	970729DA80L			0.69	91
H507	110-513	97082539L			1.64	95
H508	110-525	97082540L			2.55	95

DOB = dibromooctafluorobiphenyl

No dry weight analysis was performed for samples in this project, as sample sizes were small, and calculations were performed on a wet weight basis.

§ Flagged samples were less than 1.5g in size, and represented between 10% and 50% of the usual 3g sample size.

Table 1A-p2: Sample Information for tissues analyzed for chlorinated hydrocarbons as part of the 1997 Hylebos Salmon Exposure/Growth Study.

Set #	Sample#	Field Sample #s		Lipid (%)	Sample Wt. (g)	DOB Recovery (%)
Tissue - whole body						
H510	110-558	970715DA31B	original	2.1%	5.27	96
H515	110-622	970715DA31B	duplicate	0.4%	4.77	95
H510	110-559	970715DA32B		1.7%	5.09	93
H513	110-594	97082539B		6.4%	4.96	98
H513	110-595	97082540B		7.5%	5.11	97
H512	110-582	970929DA79B		2.5%	4.58	94
H512	110-583	9709729DA80B		2.8%	5.12	97
Exposure Group HWSE-P						
Tissue - liver						
H508	110-498	970715DA29L			0.58 §	94
H508	110-499	970715DA30L			0.56 §	92
H506	110-500	970729DA70L			0.70 §	93
H507	110-511	970729DA71L			0.54 §	94
H507	110-512	97082543L			1.64	91
H508	110-524	97082544L			2.02	97
Tissue - whole body						
H510	110-560	970715DA29B	original	2.3%	4.93	98
H511	110-569	970715DA29B	duplicate	1.9%	4.57	98
H510	110-557	970715DA30B		2.1%	5.28	95
H510	110-556	970729DA70B		3.1%	5.13	101
H512	110-580	970729DA71B		2.9%	5.33	99
H512	110-581	97082543B		5.3%	5.23	97
H513	110-593	97082544B		5.7%	5.23	99
Exposure Group NONE						
Tissue - liver						
H508	110-526	97062604L			0.38 §	93
H508	110-527	97062605L			0.42 §	90
H507	110-516	970717DA005L			0.34 §	85
H507	110-517	970717DA006L			0.31 §	88
Tissue - whole body						
H513	110-596	97062604B		1.9%	5.09	93
H513	110-597	97062605B		2.6%	5.22	98
H512	110-586	970717DA005B		1.9%	4.44	91
H512	110-587	970717DA006B		1.7%	5.01	92
Exposure Group NQSE						
Tissue - liver						
H506	110-503	970715DA26L			0.53 §	90
H506	110-504	970715DA27L			0.57 §	89
H508	110-528	970729DA66L			0.54 §	91
H508	110-529	97082557L			2.17	91

DOB = dibromooctafluorobiphenyl

No dry weight analysis was performed for samples in this project, as sample sizes were small, and calculations were performed on a wet weight basis.

§ Flagged samples were less than 1.5g in size and represented between 10% and 50% of the usual 3g sample size.

Table 1A-p3: Sample information for tissues analyzed for chlorinated hydrocarbons as part of the 1997 Hylebos Salmon Exposure/Growth Study.

Set #	Sample#	Field Sample #s		Lipid (%)	Sample Wt. (g)	DOB Recovery (%)
H508	110-530	97082558L			2.51	93
H507	110-518	970929DA65L			0.57 §	88
Tissue - whole body						
H512	110-584	970715DA26B	original	2.2%	4.73	89
H513	110-601	970715DA26B	duplicate	2.6%	5.28	91
H512	110-585	970715DA27B		2.3%	5.16	92
H513	110-598	970729DA65B		3.5%	5.12	92
H513	110-599	970729DA66B		2.9%	5.40	95
H513	110-600	97082557B		5.9%	5.51	92
H515	110-621	97082558B		5.8%	5.20	97
Exposure Group PCBS						
Tissue - liver						
H511	110-565	970715DA40L			0.49 §	97
H511	110-566	970729DA82L			0.61 §	95
H511	110-567	970729DA83L			0.60 §	97
H508	110-531	97082535L			3.25	94
H508	110-532	97082536L			1.27 §	89
H515	110-626	97082537L			2.28	94
H515	110-625	97082538L			2.16	94
Tissue - whole body						
H511	110-570	970715DA40B		1.9%	5.19	97
H511	110-571	970715DA41B		2.5%	5.09	94
H511	110-572	970729DA82B	original	2.7%	4.92	94
H515	110-620	970729DA82B	duplicate	3.0%	5.18	94
H511	110-573	970729DA83B		2.6%	4.66	92
H515R	110-618	97082535B		6.1%	4.93	96
H515	110-619	97082536B		5.8%	4.90	93

DOB = dibromooctafluorobiphenyl

No dry weight analysis was performed for samples in this project, as sample sizes were small, and calculations were performed or a wet weight basis.

§ Flagged samples were less than 1.5g in size, and represented between 10% and 50% of the usual 3g sample size.

Table 1B-p1: Concentrations (ng/g, wet weight) of pesticides and hexachlorobutadiene in tissues analyzed as part of the 1997 Hylebos Salmon Exposure/Growth Study.

Sample#	Field Sample#	HCBD	HCB	Lind	Hept	Aldrin	HPE	Oxy-Chlor	γ-Chlor	α-Chlor	t-Nona	Dieldrin	c-Nona	Mirex	o,p'-DDE	p,p'-DDE	o,p'-DDD	p,p'-DDD	o,p'-DDT	p,p'-DDT
Exposure Group CARRIER																				
Tissue - liver																				
110-495	970715DA22L	< 0.47	0.61	< 0.78	< 0.51	< 1.9	< 1	< 0.75	< 0.87	< 0.82	1.5	< 1.1	< 0.86	< 0.63	< 1.3	38	< 1.2	3.6	< 0.95	< 1.1
110-496	970715DA23L	< 0.39	0.41	< 0.66	< 0.43	< 1.6	< 0.87	< 0.63	< 0.73	< 0.69	1.6	< 0.91	< 0.72	< 0.53	< 1.1	46	< 1	3.8	< 0.8	< 0.91
110-497	970729DA67L	< 0.35	0.41	< 0.59	< 0.38	< 1.4	< 0.77	< 0.56	< 0.66	< 0.61	1.1	2	< 0.65	< 0.47	< 0.98	28	< 0.9	2.8	< 0.71	< 0.82
110-509	970729DA68L	< 0.29	0.4	< 0.37	< 0.52	< 0.42	< 2.1	< 1.1	< 0.33	< 0.32	5.9	< 0.38	< 0.3	< 0.33	< 3.1	9.1	< 2.3	1.1	< 1.5	< 0.61
110-510	97082553L	< 0.082	0.32	< 0.11	< 0.15	< 0.12	1.9	< 0.32	< 0.093	0.18	1.7	0.22	< 0.085	< 0.095	< 0.88	3.3	< 0.65	0.53	< 0.44	< 0.17
110-523	97082554L	0.22	0.28	< 0.1	< 0.14	8.8	1.5	< 0.28	< 0.088	0.2	1.4	0.22	< 0.08	< 0.09	< 0.85	3.9	< 0.6	0.53	0.87	< 0.17
Tissue - whole body																				
110-568	970715DA22B	< 0.038	0.32	< 0.042	< 0.047	< 0.049	0.61	0.53	0.14	0.44	1.4	0.3	0.17	0.043	0.65	27	0.53	1.4	0.59	0.45
110-554	970715DA23B	0.089	0.23	< 0.038	< 0.046	< 0.044	0.58	0.5	0.087	0.3	1.2	0.14	0.14	0.087	0.62	27	0.55	1.1	0.5	0.43
110-555	970729DA67B	0.082	0.37	< 0.056	< 0.067	< 0.064	0.66	0.55	0.11	0.43	1.4	0.24	0.16	< 0.051	0.7	27	0.61	1.3	0.54	0.47
110-578	970729DA68B	< 0.038	0.37	< 0.045	0.11	0.1	0.71	0.6	0.12	0.4	1.3	0.28	0.16	0.075	0.73	27	0.59	1.4	0.53	0.48
110-579	97082553B	< 0.042	0.71	0.08	< 0.067	< 0.059	0.78	0.62	0.19	0.65	1.4	0.56	0.18	< 0.048	0.75	23	0.65	1.9	0.66	0.66
110-592	97082554B	< 0.58	1.3	< 0.72	< 0.92	< 0.81	< 3.7	< 2.1	< 0.63	1.4	2.6	1.2	< 0.58	< 0.67	< 5.5	27	< 4.2	2.9	< 2.6	< 1.1
Exposure Group HCBD																				
Tissue - liver																				
110-537	970715DA34L	3100	4.6	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-538	970715DA35L	2700	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-539	970729DA76L	89	2	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-540	970729DA77L	20	1.7	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-541	97082559L	0.59	0.43	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-542	97082560L	0.38	0.39	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-623	97082561L	0.36	0.39	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-624	97082562L	< 0.12	0.36	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Tissue - whole body																				
110-543	970715DA34B	2600	4.5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-544	970715DA35B	2300	4.6	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-545	970729DA76B	100	2.6	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-546	970729DA77B	18	1.7	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-551	97082559B	1.5	0.99	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-553	97082559B	1.5	0.96	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-552	97082560B	1.7	0.91	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Exposure Group HWSE-M																				
Tissue - liver																				
110-501	970715DA31L	4.2	37	< 0.58	< 0.38	< 1.4	7.8	< 0.56	< 0.65	0.71	1.6	1.5	< 0.64	< 0.47	< 0.98	44	< 0.89	4.6	< 0.71	< 0.81
110-502	970715DA32L	0.99	29	< 0.63	< 0.41	< 1.5	8.2	< 0.6	< 0.71	0.79	2.1	< 0.87	< 0.7	< 0.51	< 1.1	69	< 0.97	5.5	< 0.77	1
110-514	970729DA79L	< 0.27	5.6	< 0.35	< 0.49	< 0.39	5.9	< 1	< 0.3	< 0.3	4.1	< 0.35	< 0.28	< 0.31	< 2.9	7.3	< 2.1	0.88	< 1.4	< 0.57
110-515	970729DA80L	< 0.25	7.2	< 0.32	< 0.45	< 0.36	6	< 0.97	< 0.28	< 0.28	4.1	< 0.33	< 0.26	< 0.29	< 2.7	6.7	< 2	0.85	< 1.3	< 0.53
110-513	97082539L	< 0.1	0.84	< 0.13	< 0.19	< 0.15	2.2	< 0.4	< 0.12	0.18	1.8	0.24	< 0.11	< 0.12	< 1.1	2.9	< 0.82	0.51	< 0.55	< 0.22
110-525	97082540L	0.24	0.97	< 0.088	< 0.12	2.9	1.4	< 0.25	0.079	0.2	1.2	0.22	< 0.07	< 0.079	< 0.74	4	< 0.53	0.5	0.72	< 0.14
Tissue - whole body																				
110-558	970715DA31B	7.1	21	0.14	< 0.047	< 0.045	3.8	0.48	0.13	0.4	1.4	0.18	0.16	0.042	0.69	25	0.59	1.5	0.57	0.42

HCBD = hexachlorobutadiene; HCB = hexachlorobenzene; Lind = lindane; Hept = heptachlor; HPE = heptachlorepoxide; Oxy-Chlor = oxychlordane; γ - Chlor = gamma-chlordane; α - Chlor = alpha-chlordane; t - Nona = trans-nonachlor; c - Nona = cis-nonachlor.

NR Samples in the PCB and HCBD exposure groups were not analyzed for pesticides other than HCB and HCBD. NR is repored in place of concentrations for pesticides that were not analyzed in these samples.

Table 1B-p2: Concentrations (ng/g, wet weight) of pesticides and hexachlorobutadiene in tissues analyzed as part of the 1997 Hylebos Salmon Exposure/Growth Study.

Sample#	Field Sample#	HCBD	HCB	Lind	Hept	Aldrin	HPE	Oxy-Chlor	γ-Chlor	α-Chlor	t-Nona	Dieldrin	c-Nona	Mirex	o,p'-DDE	p,p'-DDE	o,p'-DDD	p,p'-DDD	o,p'-DDT	p,p'-DDT
110-522	970715DA31B	6.9	20	0.08	< 0.098	< 0.061	3.8	0.8	0.12	0.35	1.4	0.22	0.16	0.061	0.73	32	0.64	1.6	0.49	0.5
110-559	970715DA32B	0.77	12	0.077	< 0.059	< 0.057	2.8	0.48	0.097	0.28	1.2	0.1	0.14	< 0.045	0.66	25	0.57	0.99	0.51	0.49
110-594	97082539B	< 0.036	2.5	0.073	< 0.057	< 0.05	1.3	0.59	0.18	0.66	1.5	0.5	0.18	< 0.041	0.71	30	0.67	1.8	0.72	0.62
110-595	97082540B	< 0.025	3.4	0.09	< 0.04	< 0.036	1.5	0.58	0.2	0.75	1.7	0.59	0.2	0.03	0.71	32	0.68	2.2	0.76	0.68
110-582	970929DA79B	0.12	7.8	< 0.051	< 0.065	0.11	2.3	0.6	0.12	0.39	1.3	0.29	0.15	0.05	0.73	24	0.61	1.4	0.48	0.55
110-583	9709729DA80B	0.053	8.9	< 0.057	< 0.073	0.11	2.7	0.55	0.13	0.44	1.4	0.31	0.17	0.054	0.71	26	0.58	1.5	0.45	0.61
Expcsure Group HWSE-P																				
Tissue - liver																				
110-498	970715DA29L	1.7	20	< 0.51	< 0.33	< 1.2	5.8	< 0.49	< 0.57	0.57	1.4	< 0.71	< 0.57	< 0.41	< 0.86	37	< 0.79	3.3	< 0.63	< 0.72
110-499	970715DA30L	0.85	21	< 0.49	< 0.32	< 1.2	6.6	< 0.47	< 0.55	0.53	1.5	< 0.68	< 0.54	0.43	< 0.82	42	< 0.75	3.3	< 0.6	< 0.68
110-500	970729DA70L	< 0.18	6	< 0.29	< 0.19	< 0.7	2.5	< 0.28	0.44	0.52	0.98	0.43	< 0.32	< 0.24	< 0.49	27	< 0.45	2.6	0.49	< 0.41
110-511	970729DA71L	< 0.29	6.2	< 0.38	< 0.53	< 0.42	7.5	< 1.1	< 0.33	< 0.32	5.2	< 0.38	< 0.3	< 0.34	< 3.1	7.4	< 2.3	0.88	< 1.6	< 0.62
110-512	97082543L	< 0.11	0.7	< 0.14	< 0.2	< 0.16	2.2	< 0.43	0.13	0.18	1.8	0.24	< 0.11	< 0.13	< 1.2	3.3	< 0.87	0.58	< 0.58	< 0.23
110-524	97082544L	0.26	0.89	< 0.11	< 0.16	2	1.7	< 0.32	< 0.1	0.21	1.5	0.22	< 0.091	< 0.1	< 0.97	4.5	< 0.69	0.57	0.89	< 0.19
Tissue - whole body																				
110-560	970715DA29B	3	19	0.38	< 0.058	< 0.056	3.7	0.49	0.11	0.36	1.5	0.095	0.16	0.045	0.73	23	0.55	1.2	0.6	0.54
110-569	970715DA29B	2.6	18	0.24	< 0.058	< 0.058	3.2	< 0.13	0.1	0.3	1.3	0.12	0.14	< 0.049	0.7	21	0.57	0.98	0.52	0.44
110-557	970715DA30B	0.94	18	0.38	< 0.06	< 0.058	3.8	< 0.14	0.073	0.28	1.4	0.078	0.15	0.17	0.66	24	0.53	1	0.54	0.51
110-556	970729DA70B	0.22	8.1	0.19	< 0.066	< 0.063	2.1	< 0.15	0.14	0.44	1.4	0.19	0.16	0.14	0.7	24	0.58	1.4	0.56	0.52
110-560	970729DA71B	< 0.036	8.1	0.1	< 0.057	< 0.051	2.9	0.52	0.12	0.41	1.4	0.31	0.16	0.05	0.68	26	0.56	1.5	0.43	0.57
110-561	97082543B	< 0.039	1.8	0.087	< 0.061	< 0.054	1.2	0.57	0.18	0.57	1.4	0.5	0.16	0.048	0.68	22	0.59	1.7	0.58	0.65
110-563	97082544B	< 0.033	1.9	0.11	< 0.052	< 0.046	1.2	0.58	0.18	0.66	1.6	0.51	0.18	< 0.038	0.67	32	0.64	1.8	0.72	0.6
Exposure Group NONE																				
Tissue - liver																				
110-526	97062604L	1.3	0.59	< 0.52	< 0.74	1.7	< 2.9	< 1.5	< 046	0.68	7.6	< 0.53	< 0.42	< 0.47	< 4.4	25	13	2.2	< 2.1	< 086
110-527	97062605L	1.2	0.51	< 0.51	< 0.71	7	< 2.8	< 1.4	< 044	0.51	6.6	< 0.51	< 0.41	< 0.46	< 4.3	15	< 3	1.6	< 2.1	< 083
110-516	970717DA005L	< 0.55	< 055	< 0.71	< 01	< 0.79	< 4	< 2.1	< 062	< 0.61	8.5	< 0.72	< 0.57	< 0.63	< 5.9	22	< 4.3	1.7	< 2.9	< 1.2
110-517	970717DA006L	< 0.52	< 052	< 0.67	< 0.94	< 0.74	< 3.8	< 2	< 058	< 0.57	9	< 0.68	< 0.53	< 0.6	< 5.5	19	< 4.1	1.4	< 2.7	< 1.1
Tissue - whole body																				
110-598	97062604B	< 0.03	0.43	< 0.037	< 0.048	< 0.042	0.69	0.64	0.16	0.52	1.7	0.29	0.21	0.09	< 0.28	44	0.59	1.8	0.64	0.48
110-597	97062605B	< 0.029	0.51	0.043	< 0.046	< 0.041	0.7	0.64	0.18	0.6	1.7	0.37	0.21	0.084	< 0.27	43	0.58	2	0.64	0.49
110-588	970717DA005B	< 0.043	0.18	< 0.054	< 0.069	< 0.061	0.69	0.59	0.069	0.23	1.2	0.12	0.13	0.087	< 0.41	26	0.58	0.89	0.51	0.41
110-587	970717DA006B	< 0.046	0.17	< 0.057	< 0.074	< 0.065	0.63	0.53	0.069	0.22	1	0.12	0.12	0.084	< 0.44	23	0.52	0.86	0.46	0.39
Exposure Group NOSE																				
Tissue - liver																				
110-503	970715DA26L	< 0.32	0.44	< 0.54	< 0.35	< 1.3	< 0.71	< 0.52	< 0.8	0.69	1.3	< 0.75	< 0.59	< 0.44	< 0.9	35	< 0.83	3.5	< 0.66	< 075
110-504	970715DA27L	< 0.3	0.38	< 0.5	< 0.32	< 1.2	< 0.66	< 0.48	< 056	0.61	1.2	< 0.69	< 0.55	< 0.4	< 0.83	31	< 0.76	3.2	< 0.61	< 069
110-529	970729DA86L	0.85	0.4	< 0.44	< 0.62	1.6	< 2.4	< 1.2	< 038	< 0.38	5.1	< 0.45	< 0.35	< 0.39	< 3.7	11	< 2.6	1.2	< 1.8	< 072
110-529	97082557L	0.37	0.28	< 0.099	< 0.14	1.7	< 0.54	< 0.28	0.1	0.21	1.4	0.24	< 0.079	< 0.088	< 0.84	4.3	< 0.59	0.55	0.87	< 016
110-530	97082558L	0.3	0.29	< 0.093	< 0.13	0.97	< 0.51	< 0.26	0.082	0.22	1.3	0.23	< 0.074	< 0.083	< 0.78	4	< 0.55	0.54	0.79	< 015
110-518	970929DA85L	< 0.23	0.4	< 0.3	< 0.41	< 0.33	< 1.7	< 0.88	< 026	0.27	4.8	< 0.3	< 0.24	< 0.26	< 2.4	7.1	< 1.8	0.89	< 1.2	< 048
Tissue - whole body																				
110-581	970715DA26B	< 0.079	0.33	< 0.098	< 0.13	< 0.11	0.69	0.61	0.13	0.43	1.3	0.27	0.16	< 0.091	< 0.75	23	< 0.57	1.3	0.61	0.54

HCBD = hexachlorobutadiene; HCB = hexachlorobenzene; Lind = lindane; Hept = heptachlor; HPE = heptachlorepoxide; Oxy-Chlor = oxychlordane; γ - Chlor = gamma-chlordane; α - Chlor = alpha-chlordane; t - Nona = trans-nonachlor; c - Nona = cis-nonachlor.

NR Samples in the PCB and HCBD exposure groups were not analyzed for pesticides other than HCB and HCBD. NR is reported in place of concentrations for pesticides that were not analyzed in these samples.

Table 1B-p3: Concentrations (ng/g, wet weight) of pesticides and hexachlorobutadiene in tissues analyzed as part of the 1997 Hylebos Salmon Exposure/Growth Study.

Sample#	Field Sample#	HCBD	HCB	Lind	Hept	Aldrin	HPE	Oxy-Chlor	γ-Chlor	α-Chlor	t-Nona	Dieldrin	c-Nona	Mirex	o,p'-DDE	p,p'-DDE	o,p'-DDD	p,p'-DDD	o,p'-DDT	p,p'-DDT
110-501	970715DA26B	< 0.023	0.41	0.031	< 0.037	< 0.032	0.65	0.57	0.12	0.44	1.4	0.21	0.15	0.073	0.61	35	0.56	1.5	0.64	0.47
110-585	970715DA27B	< 0.036	0.37	< 0.044	< 0.057	< 0.05	0.63	0.57	0.13	0.43	1.4	0.26	0.17	0.078	0.65	27	0.55	1.6	0.57	0.57
110-598	970729DA65B	< 0.032	0.46	0.047	< 0.051	< 0.045	0.69	0.59	0.13	0.47	1.4	0.29	0.16	0.08	0.65	33	0.61	1.5	0.63	0.44
110-599	970729DA66B	< 0.03	0.39	0.041	< 0.048	< 0.042	0.65	0.56	0.12	0.44	1.4	0.24	0.16	0.079	0.6	34	0.56	1.4	0.6	0.45
110-600	97082557B	< 0.029	0.74	0.075	< 0.046	< 0.041	0.72	0.59	0.18	0.67	1.5	0.53	0.18	< 0.033	0.62	30	0.61	1.8	0.7	0.61
110-621	97082558B	< 0.044	0.73	0.087	< 0.11	< 0.067	0.86	0.82	0.22	0.62	1.5	0.57	0.2	< 0.066	0.67	30	0.72	2.1	0.72	0.88
Exposure Group PCBS																				
Tissue - liver																				
110-565	970715DA40L	< 0.35	0.44	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-566	970729DA82L	< 0.29	0.42	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-567	970729DA83L	< 0.32	0.4	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-531	97082535L	0.3	0.3	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-532	97082536L	0.62	0.29	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-626	97082537L	< 0.11	0.29	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-625	97082538L	< 0.13	0.27	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Tissue - whole body																				
110-570	970715DA40B	< 0.036	0.32	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-571	970715DA41B	< 0.044	0.34	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-572	970729DA82B	< 0.043	0.36	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-620	970729DA82B	< 0.061	0.35	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-573	970729DA83B	< 0.056	0.34	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-618	97082535B	< 0.053	0.7	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110-619	97082536B	< 0.049	0.7	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

HCBD = hexachlorobutadiene; HCB = hexachlorobenzene; Lind = lindane; Hept = heptachlor; HPE = heptachlorepoxide; Oxy-Chlor = oxychlordane; γ-Chlor = gamma-chlordane; α-Chlor = alpha-chlordane; t-Nona = trans-nonachlor; c-Nona = cis-nonachlor.

NR Samples in the PCB and HCBD exposure groups were not analyzed for pesticides other than HCB and HCBD. NR is reported in place of concentrations for pesticides that were not analyzed in these samples.

Table 1C-pt: Concentrations (ng/g, wet weight) of chlorobiphenyl congeners (by IUPAC number) in tissues analyzed as part of the 1997 Hylebos Salmon Exposure/Growth Study.

Sample#	Field Sample#	18	28	44	52	66	101¥	105	118	128	138¥	153¥	170	180Å	187	195	205	209	PCBs (Est. Total)
Exposure Group CARRIER																			
Tissue - liver																			
110-495	970715DA22L	2	28	4.5	1.6	< 0.99	3.1	1.2	3.4	0.79	5.9	5.5	0.73	0.67	1.4	< 0.43	< 0.42	0.65	68
110-496	970715DA23L	2.4	23	4.1	1.5	< 0.83	3.7	1.4	3.9	0.91	6.8	6.7	0.84	0.8	1.7	< 0.36	< 0.35	0.84	76
110-497	970729DA67L	2.5	32	3.4	1.2	< 0.74	2.7	1.1	2.9	0.63	5.9	4.7	0.65	0.61	1.2	< 0.32	< 0.31	1.2	64
110-509	970729DA68L	3.1	32	2.9	1.9	0.68	2.3	0.56	1.6	0.37	3.5	3.5	0.54	0.45	0.99	< 0.23	< 0.24	0.35	52
110-510	97082553L	1.2	0.69	0.88	0.77	0.27	0.84	0.18	0.52	0.13	1.2	1.2	0.17	0.18	0.38	< 0.066	< 0.063	0.2	18
110-523	97082554L	0.52	0.44	0.69	0.51	< 0.13	0.73	0.19	0.52	0.13	1.1	1.1	0.14	0.15	0.33	< 0.062	< 0.064	0.3	14
Tissue - whole body																			
110-568	970715DA22B	0.25	0.22	0.45	0.8	0.26	2	0.38	1.5	0.34	3.2	3.7	0.29	0.54	0.87	0.059	0.03	< 0.036	30
110-554	970715DA23B	0.24	0.22	0.38	0.57	0.3	1.8	0.37	1.2	0.27	2.7	3.4	0.3	0.55	0.88	0.066	0.064	< 0.032	26
110-555	970729DA67B	0.24	0.21	0.41	0.63	0.29	1.8	0.46	1.2	0.28	2.6	3.3	0.29	0.52	0.88	0.066	0.061	< 0.046	26
110-578	970729DA68B	0.23	0.23	0.4	0.66	0.24	1.8	0.28	1.2	0.28	2.5	3.4	0.28	0.49	0.86	0.059	0.057	< 0.034	26
110-579	97082553B	0.34	0.37	0.55	1.1	0.27	1.9	0.29	1.3	0.34	2.5	3.3	0.25	0.5	0.82	0.054	0.052	< 0.039	28
110-592	97082554B	< 2.1	< 12	0.95	2.3	< 0.92	3.6	< 0.59	1.8	0.55	3.6	5.3	< 0.45	0.67	1.4	< 0.45	< 0.47	< 0.54	40
Exposure Group HCBD																			
Tissue - liver																			
110-537	970715DA34L	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0
110-538	970715DA35L	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0
110-539	970728DA76L	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0
110-540	970729DA77L	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0
110-541	97082559L	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0
110-542	97082560L	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0
110-623	97082561L	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0
110-624	97082562L	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0
Tissue - whole body																			
110-543	970715DA34B	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0
110-544	970715DA35B	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0
110-545	970729DA76B	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0
110-546	970729DA77B	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0
110-551	97082559B	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0
110-553	97082559B	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0
110-552	97082560B	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0
Exposure Group HWSE-M																			
Tissue - liver																			
110-501	970715DA31L	1.2	21	4.1	1.6	1.7	3.5	0.98	4	0.84	7.8	6.9	1.4	1	2.1	1.4	7.2	34	160
110-502	970715DA32L	2.5	33	4.7	1.9	2.3	5	1.7	5.6	1.2	10	10	1.7	1.5	2.9	1.4	6.3	27	180
110-514	970729DA79L	1.4	11	2.1	1.3	0.62	1.8	0.41	1.2	0.32	4	3.5	0.7	0.59	1.1	0.46	1.5	5.5	55
110-515	970729DA80L	1.7	1	2.2	1.3	0.51	1.7	0.41	1.1	0.3	3.2	2.8	0.51	0.43	0.95	0.43	1.6	7.9	56

‡ Concentrations of these analytes were calcuated using ar 8-pt calibration curve.
Δ Concentrations of these analytes were estimated because they exceeded the GC-ECD calibration range.
† Concentrations of these analytes were estimated because they saturated the detector; the actual concentrations are probably somewhat greater than this estimated value.
NR Samples in the HCBD exposure group were not analyzed for PCBs. NR is reported in place of concentrations of congeners that were not analyzed in these samples.

¥PCBs 101 and 90 are not resolved by our gas chromatographic procedure, therefore we report their combined concentrations as "101".
PCBs 138, 163, and 164 are not resolved byour gas chromatographic procedure, therefore we report their combined concentrations as "138".
PCBs 153 and 132 are not resolved by our gas chromatographic procedure, therefore we report their combined concentrations as "153".

Final

Å PCB180 coelutes with an unidentified compound and its concentration s estimated based on a percentage determined by GC/MS.

PCBs (Est. Total) is an estimate of the total PCBs obtained by multiplying the sum of the concentrations of the 17 individual congeners reported here by 2.

9/3/98

Table 1C-p2: Concentrations (ng/g, wet weight) of chlorobiphenyl congeners (by IUPAC number) in tissues analyzed as part of the 1997 Hylebos Salmon Exposure/Growth Study.

Sample#	Field Sample#	16	28	44	52	66	101¥	105	118	128	138¥	153¥	170	180Å	187	195	205	209	PCBs (Est. Total)
110-513	97082539L	0.88	0.53	09	0.73	0.25	0.8	0.21	0.51	0.12	1.4	1.2	0.17	0.17	0.37	< 0.033	0.15	0.61	18
110-525	97082540L	0.59	0.4	0.65	0.52	0.12	0.73	0.15	0.49	0.11	1	1.1	0.15	0.16	0.35	0.087	0.16	1.1	16
Tissue - whole body																			
110-558	970715DA31B	0.32	0.32	0.49	0.86	0.53	1.8	0.4	1.4	0.34	2.9	3.7	0.42	0.66	1.1	0.37	2.2	5.3	46
110-622	970715DA31B	0.58	0.29	0.69	0.9	0.48	2	0.39	1.4	0.33	2.8	3.5	0.45	0.55	1	0.36	2	5.1	46
110-559	970715DA32B	0.16	0.2	0.41	0.63	0.41	1.7	0.38	1.3	0.3	2.8	3.7	0.4	0.62	1.1	0.34	1.8	4.3	41
110-594	97082539B	0.36	0.38	0.69	1.2	0.31	2	0.1	1.3	0.32	2.6	3.6	0.25	0.54	0.86	0.13	0.59	1.6	34
110-595	97082540B	0.36	0.42	0.75	1.3	0.31	2.1	0.11	1.4	0.36	2.9	3.9	0.28	0.66	0.93	0.15	0.72	1.9	37
110-582	970929DA79B	0.26	0.28	0.65	0.7	0.3	1.8	0.3	1.3	0.31	2.7	3.5	0.28	0.57	0.94	0.26	1.3	3.3	38
110-583	9709729DA80	0.27	0.29	0.49	0.76	0.31	2	0.32	1.4	0.32	2.8	3.7	0.3	0.6	1	0.31	1.6	4.2	42
Exposure Group HWSE-P																			
Tissue - liver																			
110-498	970715DA29L	2.2	2.1	38	1.4	1.2	3.4	1.2	3.8	0.83	7.3	6.1	1.1	0.86	1.9	1.3	7.1	34	160
110-499	970715DA30L	1.5	1.8	4	1.6	1.3	3.9	1.4	4.5	0.92	7.9	7	1.2	0.96	2.2	1.4	8.1	37	170
110-500	970729DA70L	1.8	2	3	1.2	1.1	2.6	0.93	3.2	0.62	5.4	4.7	0.62	0.53	1.2	0.48	2	11	86
110-511	970729DA71L	2.8	1.8	28	2	0.68	2.4	0.55	1.6	0.37	3.5	3.6	0.64	0.51	1.1	0.53	2.2	11	76
110-512	97082543L	1.5	0.64	0.98	0.77	0.27	0.9	0.21	0.6	0.14	1.4	1.4	0.19	0.19	0.42	0.091	0.16	0.77	21
110-524	97082544L	0.65	0.48	0.79	0.63	< 0.15	0.86	0.19	0.57	0.13	1.2	1.2	0.15	0.16	0.37	0.085	0.14	0.93	17
Tissue - whole body																			
110-560	970715DA29B	0.3	0.28	0.44	0.95	0.55	2.1	0.44	1.5	0.38	3.3	3.9	0.43	0.62	1.1	0.41	2.5	6.2	51
110-569	970715DA29B	0.21	0.21	0.48	0.86	0.31	1.9	0.38	1.4	0.35	3.2	3.7	0.4	0.61	1.1	0.4	2.5	6	48
110-557	970715DA30B	0.2	0.21	0.36	0.67	0.62	2.1	0.39	1.6	0.37	3.4	4.2	0.48	0.69	1.2	0.47	2.8	6.6	53
110-556	970729DA70B	0.29	0.21	0.51	0.83	0.38	2	0.46	1.3	0.33	2.9	3.5	0.3	0.56	0.96	0.27	1.6	4.2	41
110-580	970729DA71B	0.23	0.26	0.59	0.86	0.32	2.2	0.35	1.6	0.36	3.2	4.1	0.35	0.68	1.1	0.36	2.1	4.8	47
110-581	97082543B	0.29	0.33	0.58	1.1	0.34	2	0.29	1.3	0.3	2.5	3.2	0.22	0.5	0.8	0.15	0.64	1.7	32
110-593	97082544B	0.4	0.38	0.65	1.3	0.29	2.2	0.11	1.4	0.33	2.8	3.8	0.26	0.58	0.89	0.14	0.56	1.5	35
Exposure Group NONE																			
Tissue - liver																			
110-526	97062604L	2.8	2.8	45	4.7	1.1	5.3	1.4	4.4	1	6.9	7.5	0.86	0.76	1.6	< 0.32	< 0.33	0.86	93
110-527	97062605L	2.3	2.2	37	3.4	0.72	3.4	0.84	2.5	0.56	6.5	4.7	0.64	0.54	1.1	< 0.32	< 0.32	0.5	67
110-516	970717DA005	3.5	2.1	39	2.3	< 0.92	4.1	1.1	2.8	0.8	7.6	7.7	1.4	1.2	2.4	< 0.44	< 0.45	< 0.52	82
110-517	970717DA006	2.9	3	44	2.6	< 0.87	4.1	1.2	2.8	0.76	7.7	7.8	1.5	1.3	2.4	< 0.41	< 0.43	< 0.49	85
Tissue - whole body																			
110-596	97062604B	0.84	0.94	12	2.7	1	3.2	0.53	2.1	0.37	3.4	4.3	0.31	0.68	0.97	0.064	0.064	< 0.028	45
110-597	97062605B	1.1	1.2	13	2.8	0.92	3	0.55	2	0.36	3.3	4.1	0.29	0.68	0.93	0.063	0.062	< 0.027	45
110-586	970717DA005	0.21	0.18	0.39	0.51	0.3	1.7	0.24	1.3	0.29	2.8	3.9	0.37	0.61	1	0.076	0.071	< 0.041	28
110-587	970717DA006	0.21	0.16	0.35	0.48	0.27	1.5	0.21	1.1	0.26	2.4	3.3	0.27	0.46	0.84	0.061	0.062	< 0.044	24
Exposure Group NQSE																			

‡ Concentrations of these analytes were calculated using an 8-pt calibration curve.
Δ Concentrations of these analytes were estimated because they exceeded the GC-ECD calibration range.
† Concentrations of these analytes were estimated because they saturated the detector; the actua concentrations are probably somewhat greater than this estimated value.
NR Samples in the HCBD exposure group were not analyzed for PCBs. NR is reported in place of concentrations of congeners that were not analyzed in these samples.

¥PCBs 101 and 90 are not resoved by our gas chromatographic procedure, therefore we report their combined concentrations as "101".
PCBs 138, 163, and 164 are not resolved by our gas chromatographic procedure, therefore we report their combined concentrations as "138".
PCBs 153 and 132 are not resolved by our gas chromatographic procedure, therefore we report their combined concentrations as "153".

Final

Å PCB180 coelutes with an unidentified compound and its concentration is estimated based on a percentage determined by GC/MS.

PCBs (Est. Total) is an estimate of the total PCBs obtained by multiplying the sum of the concentrations of the 17 individual congeners reported here by 2.

Table 1C-p3: Concentrations (ng/g, wet weight) of chlorobiphenyl congeners (by IUPAC number) in tissues analyzed as part of the 1997 Hylebos Salmon Exposure/Growth Study.

Sample#	Field Sample#	18	28	44	52	66	101¥	105	118	128	138¥	153¥	170	180Å	187	195	206	209	PCBs (Est. Total)
Tissue - liver																			
110-583	970715DA26L	2.7	3.7	3.7	1.5	1.5	3.3	1.4	3.9	0.81	6.2	5.9	0.78	0.73	1.4	< 0.3	< 0.29	0.84	77
110-584	970715DA27L	2.7	2.7	3.4	1.2	1.1	2.7	1.1	3	0.69	6.1	4.7	0.53	0.57	1.1	< 0.27	< 0.27	0.84	65
110-528	970729DA66L	1.7	1.3	2.5	1.5	< 0.57	2.2	0.59	1.7	0.38	4.3	3.6	0.5	0.44	0.96	< 0.27	< 0.28	0.65	44
110-529	97082557L	0.6	0.39	0.71	0.55	0.14	0.77	0.17	0.53	0.12	1.2	1.2	0.17	0.18	0.37	< 0.061	< 0.063	0.34	15
110-530	97082558L	0.69	0.33	0.59	0.52	0.14	0.69	0.13	0.47	0.12	1.1	1.1	0.12	0.14	0.32	< 0.057	< 0.059	0.45	14
110-518	970929DA65L	2.4	1.2	2.4	1.3	< 0.38	1.7	0.48	1.2	0.29	4.3	2.6	0.44	0.38	0.78	< 0.18	< 0.19	0.79	41
Tissue - whole body																			
110-584	970715DA26B	< 0.29	0.25	0.46	0.82	0.25	1.9	0.38	1.3	0.32	2.4	3.2	0.25	0.41	0.78	< 0.062	< 0.064	< 0.074	26
110-601	970715DA26B	0.3	0.22	0.48	0.85	0.42	2	0.37	1.4	0.33	2.8	3.5	0.25	0.52	0.79	0.051	0.05	< 0.022	29
110-585	970715DA27B	0.25	0.23	0.43	0.85	0.36	2.1	0.32	1.5	0.34	2.9	3.9	0.29	0.56	0.89	0.058	0.057	< 0.033	30
110-598	970729DA65B	0.27	0.24	0.43	0.77	0.33	1.8	0.36	1.2	0.32	2.5	3.2	0.24	0.5	0.81	0.055	0.06	< 0.03	26
110-599	970729DA66B	0.24	0.19	0.4	0.72	0.35	1.8	0.33	1.3	0.3	2.6	3.4	0.25	0.52	0.83	0.065	0.055	< 0.026	27
110-600	97082557B	0.36	0.3	0.54	1.2	0.45	2	0.33	1.2	0.36	2.6	3.2	0.21	0.51	0.79	0.038	0.047	< 0.027	28
110-621	97082558B	0.46	0.37	0.66	1.7	0.63	2.7	0.5	1.9	0.38	2.9	3.7	0.27	0.46	0.77	0.04	0.049	< 0.042	35
Exposure Group PCBS																			
Tissue - liver																			
110-565	970715DA40L	14	19	490	1500Δ	240	2200Δ	970	1700Δ	520	1300Δ	1900Δ	220	210	79	7.7	4	1.8	23000
110-566	970729DA82L	5.1	5.6	200	560	110	1100Δ	470	1100	230	1100	910	94	92	34	2.9	1.5	0.42	12000
110-567	970729DA83L	4.5	5.4	220	630	130	1300Δ	480	1400	270	1200Δ	1100Δ	110	100	38	3	1.5	0.43	14000
110-531	97082535L	0.96	0.64	25	67	17	120	50	110	29	110	100	10	10	3.7	0.26	0.11	0.4	1300
110-532	97082536L	1.7	0.82	23	60	15	100	38	93	24	96	92	7.9	7.8	3	0.23	0.11	0.93	1100
110-626	97082537L	1.3	0.92	21	57	15	98	33	84	22	88	88	7.3	7.5	2.9	0.21	0.11	0.19	1100
110-625	97082538L	1.1	0.92	20	54	73	93	30	80	20	84	85	6.8	6.9	2.8	0.2	0.12	< 0.12	1100
Tissue - whole body																			
110-570	970715DA40B	10	20	410Δ	870Δ	230Δ	1200†	500Δ	880Δ	440Δ	1100†	1000†	180Δ	160Δ	57	3.6	1.6	0.3	14000
110-571	970715DA41B	12	21	440Δ	930Δ	230Δ	1300Δ	520Δ	920Δ	230Δ	1700Δ	1100Δ	190Δ	170Δ	59	3.6	1.5	0.3	15000
110-572	970729DA82B	3.9	8.8	270Δ	610Δ	200Δ	980Δ	400Δ	710Δ	360Δ	910Δ	840Δ	150Δ	140Δ	43	2.7	1.1	0.23	11000
110-620	970729DA82B	4	8.9	300Δ	670Δ	190Δ	1100Δ	440Δ	800Δ	390Δ	1000Δ	940Δ	150Δ	160Δ	44	2.5	1	0.22	12000
110-573	970729DA83B	3.4	7.9	280Δ	630Δ	280Δ	1100Δ	450Δ	790Δ	390Δ	990Δ	900Δ	160Δ	150Δ	47	2.9	1.2	0.26	12000
110-618	97082535B	1.4	1.5	78	240‡	55	430‡	150‡	330‡	82	400‡	380‡	33	39	14	0.84	0.35	0.11	4500
110-619	97082536B	1.4	2.4	78	250Δ	64	420Δ	160	320Δ	87	400Δ	380Δ	37	43	15	0.79	0.37	0.1	4500

‡ Concentrations of these analytes were calculated using an 8-pt calibration curve.
Δ Concentrations of these analytes were estimated because they exceeded the GC-ECD calibration range.
† Concentrations of these analytes were estimated because they saturated the detector; the actual concentrations are probably somewhat greater than this estimated value.
NR Samples in the HCBD exposure group were not analyzed for PCBs. NR is reported in place of concentrations of congeners that were not analyzed in these samples.

¥PCBs 101 and 90 are not resolved by our gas chromatographic procedure, therefore we report their combined concentrations as "101".
PCBs 138, 163, and 164 are not resolved by our gas chromatographic procedure, therefore we report their combined concentrations as "138".
PCBs 153 and 132 are not resolved by our gas chromatographic procedure, therefore we report their combined concentrations as "153".

Final

Å PCE180 coelutes with an unidentified compound and its concentration is estimated based on a percentage determined by GC/MS.

PCBs (Est. Total) is an estimate of the total PCBs obtained by multiplying the sum of the concentrations of the 17 individual congeners reported here by 2.

Table 1D-p1: QA: Sample Information for method blanks and standard reference material (SRM 1974a) analyzed for chlorinated hydrocarbons as part of the 1997 Hylebos Salmon Exposure/Growth Study.

Set #	Sample #		Sample Wt (g)	DOB Recovery (%)
Method Blank				
H506	110-506		0.54	87
H507	110-520		0.86	89
H508	110-534		1.73	84
H509	110-548		2.69	92
H510	110-562		5.13	87
H511	110-575		3.44	89
H512	110-589		4.92	93
H513	110-603		5.21	90
H515	110-628		3.77	90
		Average	3.14	89
		Std. Dev.	1.7	2.5
		R.S.D.	54.1%	2.8%
SRM 1974a				
H506	110-505		3.20	88
H507	110-519		3.07	85
H508	110-533		3.24	86
H509	110-547		2.93	90
H510	110-561		2.98	90
H511	110-574		3.01	88
H512	110-588		3.02	88
H513	110-602		3.08	90
H515	110-627		3.54	91
		Average	3.12	88
		Std. Dev.	0.2	1.8
		R.S.D.	5.6%	2.0%

DOB = dibromooctafluorobiphenyl

No dry weight analysis was performed for samples is this project, as sample sizes were small, and calculations were performed on a wet weight basis.

Table 1D-p1: QA: Sample information for method blanks and standard reference material (SRM 1974a) analyzed for chlorinated hydrocarbons as part of the 1997 Hylebos Salmon Exposure/Growth Study.

Set #	Sample #		Sample Wt (g)	DOB Recovery (%)
Method Blank				
H506	110-506		0.54	87
H507	110-520		0.86	89
H508	110-534		1.73	84
H509	110-548		2.69	92
H510	110-562		5.13	87
H511	110-575		3.44	89
H512	110-589		4.92	93
H513	110-603		5.21	90
H515	110-628		3.77	90
		Average	3.14	89
		Std. Dev.	1.7	2.5
		R.S.D.	54.1%	2.8%
SRM 1974a				
H506	110-505		3.20	88
H507	110-519		3.07	85
H508	110-533		3.24	86
H509	110-547		2.93	90
H510	110-561		2.98	90
H511	110-574		3.01	88
H512	110-588		3.02	88
H513	110-602		3.08	90
H515	110-627		3.54	91
		Average	3.12	88
		Std. Dev.	0.2	1.8
		R.S.D.	5.6%	2.0%

DOB = dibromooctafluorobiphenyl

No dry weight analysis was performed for samplesin this project, as sample sizes were small, and calculations were performed on a wet weight basis.

Table 1F-p1: QA: Concentrations (ng/g, wet weight) of chlorobiphenyl congeners (by IUPAC number) in method blanks and standard reference materials (SRM 1974a) analyzed as part of the 1997 Hylebos Salmon Exposure/Growth Study.

Sample #	18	28	44	52	66	101¥	105	118	128	138¥	153¥	170	180‡	187	195	206	209	PCBs (Est. Total)
Method Blank																		
110-506	< 1.1	1.8	3.2	< 0.76	0.7	1.2	0.84	2.1	< 0.38	3.3	?	< 0.31	< 0.34	< 0.4	< 0.3	< 0.29	< 0.32	30
110-520	0.77	0.7	1.5	0.67	< 0.27	0.64	0.2	0.65	< 0.14	1.2	0.87	0.21	< 0.14	0.19	< 0.13	< 0.13	< 0.15	15
110-534	0.45	0.38	0.76	0.37	< 0.19	0.5	0.19	0.56	< 0.094	0.82	0.67	< 0.088	< 0.098	< 0.12	< 0.088	< 0.091	< 0.1	9.4
110-548	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0
110-562	< 0.15	0.11	0.25	< 0.1	< 0.065	0.085	< 0.042	0.094	< 0.034	0.33	0.11	< 0.032	< 0.035	< 0.043	< 0.033	< 0.035	< 0.04	1.9
110-575	< 0.27	0.17	0.39	< 0.19	< 0.12	0.19	0.086	0.25	< 0.061	0.63	0.32	< 0.057	< 0.064	< 0.079	< 0.058	< 0.061	< 0.071	4.1
110-589	< 0.15	0.1	0.26	0.11	< 0.065	0.14	0.058	0.16	< 0.034	0.27	0.25	0.049	0.036	0.056	< 0.032	< 0.033	< 0.038	3
110-603	< 0.15	0.15	0.28	0.12	< 0.068	0.14	0.067	0.19	< 0.035	0.28	0.2	< 0.032	< 0.036	< 0.045	< 0.033	< 0.034	< 0.039	2.9
110-628	0.35	0.25	0.37	0.17	< 0.094	0.16	0.071	0.21	< 0.05	0.24	0.2	< 0.047	< 0.052	< 0.063	< 0.047	< 0.048	< 0.055	4
Average*	0.2	0.5	0.9	0.2	0.1	0.4	0.2	0.5	0.0	0.9	0.8	0.0	0.0	0.0	0.0	0.0	0.0	7.8
Std. Dev.	0.3	0.5	1.0	0.2	0.2	0.3	0.3	0.6		1.0	0.8	0.1	0.0	0.1				9.0
R.S.D.	141.1%	117.3%	110.6%	120.7%	264.6%	92.7%	134.3%	116.8%	?	108.8%	102.2%	213.5%	264.6%	203.8%	?	?	?	114.4%
SRM 1974a																		
110-505	38	13	11	16	17	19	7.7	19	2.9	20	24	0.57	1.2	4.9	0.078	< 0.048	0.1	320
110-519	37	8.5	8.8	16	14	18	4.6	16	2	17	22	0.51	0.88	3.8	0.062	< 0.04	< 0.046	270
110-533	39	9.9	9.1	16	12	19	5.2	18	2	19	24	0.58	1	4.3	0.092	< 0.045	0.08	290
110-547	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0
110-561	36	8.7	8.3	15	12	17	5.2	16	1.7	16	20	0.55	0.87	3.8	0.075	< 0.062	< 0.071	260
110-574	38	15	9.2	18	14	20	6	19	2.2	20	24	0.58	1	4.2	< 0.063	< 0.066	< 0.077	310
110-588	36	8.3	8.4	15	14	17	4.6	16	1.8	17	21	0.5	0.89	3.9	0.064	< 0.05	< 0.058	260
110-602	36	8.8	8.3	15	11	17	4.3	15	1.7	17	22	0.51	0.83	3.8	< 0.056	0.074	< 0.067	260
110-627	39	8.2	8.2	15	11	17	4.8	15	1.7	16	21	0.39	0.78	3.8	0.083	0.084	< 0.07	250
Average*	37	10.0	8.9	15.7	13.1	17.9	5.3	16.7	2.0	17.7	22.2	0.5	0.9	4.0	0.1	0.0	0.0	247.1
Std. Dev.	0.1	2.3	0.9	0.8	1.8	1.3	1.0	1.5	0.4	1.4	1.4	0.1	0.1	0.4	0.0	0.0	0.0	90.3
R.S.D.	3.0%	23.0%	9.7%	5.2%	13.8%	7.4%	19.3%	9.2%	18.9%	7.8%	6.3%	11.6%	14.1%	9.4%	59.9%	173.7%	175.1%	36.5%
SRM 1974a CC	37	9	**8.28**	**13.1**	**11.54**	**14.6**	**6.04**	**14.9**	**2.5**	**15.2**	**16.54**	**0.83**	**1.95**	**3.67**	--	--	--	
Certified 95% CI			**0.84**	**1.30**	**0.50**	**1.1**	**0.39**	**0.40**	**0.39**	**1.1**	**0.84**	**0.12**	**0.43**	**0.27**				
concentrations UCL			**12.31**	**19.44**	**16.25**	**21.20**	**8.68**	**20.66**	**3.90**	**22.01**	**23.41**	**1.01**	**3.21**	**5.59**				
(ng/g, wet wt) LCL			**4.84**	**7.67**	**7.18**	**8.78**	**3.67**	**9.43**	**1.37**	**9.17**	**10.11**	**0.33**	**0.99**	**2.34**				

CC is the certified concentration (bolded values); concentrations in plain type are advisory values only.
95% CI is the 95% confidence interval
UCL is the upper control limit (1.35 [CC + 95% CI])
LCL is the lower control limit (0.65 [CC - 95% CI])

¥PCBs 101 and 90 are not resolved by our gas chromatographic procedure, therefore we report their combined concentrations as "101".
PCBs 138, 163, and 164 are not resolved by our gas chromatographic procedure, therefore we report their combined concentrations as "138".
PCBs 153 and 132 are not resolved by our gas chromatographic procedure, therefore we report their combined concentrations as "153".

‡ PCB180 coelutes with an unidentified compound and its concentration is estimated based on a percentage determined by GC/MS; this estimate may fall below the LCL for SRM 1974a.

PCBs (Est. Total) s an estimate of the total PCBs obtained by multiplying the sum of the concentrations of the 17 individual congeners reported here by 2.

NR Samples in the HCBD exposure group were not analyzed for PCBs. NR is reported in place of concentrations of congeners that were not analyzed in these samples.

* When an analyte was detected in some, but not all of the method blanks or SRMs, the average concentration is based on the concentration when detected and zero when not detected. When an analyte was not detected in any of the method blanks or SRMs, zero is reported for the average and the Std. Dev., and a "?" is reported for the R.S.D.

Table 1G-pl: Sample information for tissues analyzed in replicate for chlorinated hydrocarbons as part of the 1997 Hylebos Salmon Exposure/Growth Study.

Set #	Sampe #	Field Sample #	Sample Type		Sample Wt (g)	Lipid (%)	DOB Recovery (%)
Exposure Group HCBD							
H510	110-551	97082559B	Tissue - whole body	original	5.12	5.3%	99
H510	110-553	97082559B	Tissue - whole body	duplicate	4.96	5.4%	98
				Average	5.04	5.3	99
				Std Dev.	0.08	0.1	0.9
				R.S.D.	1.6%	1.2%	0.9%
Exposure Group HWSE-M							
H510	110-558	970715DA31B	Tissue - whole body	original	5.27	2.1%	96
H515	110-622	970715DA31B	Tissue - whole body	duplicate	4.77	0.4%	95
				Average	5.02	1.2	96
				Std. Dev.	0.25	0.8	0.3
				R.S.D.	5.0%	66.8%	0.3%
Exposure Group HWSE-P							
H510	110-560	970715DA29B	Tissue - whole body	original	4.93	2.3%	98
H511	110-569	970715DA29B	Tissue - whole body	duplicate	4.57	1.9%	98
				Average	4.75	2.1	98
				Std. Dev.	0.18	0.2	0.1
				R.S.D.	3.8%	8.0%	0.1%
Exposure Group NQSE							
H512	110-564	970715DA26B	Tissue - whole body	orginal	4.73	2.2%	89
H513	110-601	970715DA26B	Tissue - whole body	duplicate	5.28	2.6%	91
				Average	5.01	2.4	90
				Std. Dev.	0.28	0.2	1.3
				R.S.D.	5.5%	7.6%	1.4%
Exposure Group PCBS							
H511	110-572	970729DA82B	Tissue - whole body	orginal	4.92	2.7%	94
H515	110-620	970729DA82B	Tissue - whole body	duplicate	5.18	3.0%	94
				Average	5.05	2.8	94
				Std. Dev.	0.13	0.1	0.3
				R.S.D.	2.6%	4.8%	0.4%

DOB = dibromooctafluorobiphenyl

No dry weight analysis was performed for samples in this project, as sample sizes were small, and calculations were performed on a wet weight basis.

Table 1H-p1: Concentrations (ng/g, wet weight) of pesticides and hexachlorobutadiene in tissues analyzed in replicate as part of the 1997 Hylebos Salmon Exposure/Growth Study.

Sample#		HCBD	HCB	Lind	Hept	Aldrin	HPE	Oxy-Chlor	γ-Chlor	α-Chlor	t-Nona	Dieldrin	c-Nona	Mirex	opDDE	ppDDE	opDDD	ppDDD	opDDT	ppDDT
Exposure Group HCBD																				
110551		1.5	0.99	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110553		1.5	0.96	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	Average*	1.5	1.0																	
	Std. Dev.	0.0	0.0																	
	R.S.D.	1.1%	1.3%																	
Exposure Group HWSE-M																				
110558		7.1	21	0.14	< 0.047	< 0.045	3.8	0.48	0.13	0.4	1.4	0.18	0.16	0.042	0.69	25	0.59	1.5	0.57	0.42
110622		6.9	20	0.08	< 0.098	< 0.061	3.8	0.8	0.12	0.35	1.4	0.22	0.16	0.061	0.73	32	0.64	1.6	0.49	0.5
	Average*	7.0	20.4	0.1	0.0	0.0	3.8	0.6	0.1	0.4	1.4	0.2	0.2	0.1	0.7	28.4	0.6	1.5	0.5	0.5
	Std. Dev.	0.1	0.4	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.1	0.0	0.0
	R.S.D.	1.5%	2.1%	27.5%	?	?	0.1%	24.9%	7.1%	6.1%	0.2%	8.1%	2.4%	17.9%	2.7%	11.8%	3.8%	3.6%	7.9%	9.2%
Exposure Group HWSE-P																				
110560		3	19	0.38	< 0.058	< 0.058	3.7	0.49	0.11	0.36	1.5	0.095	0.16	0.045	0.73	23	0.55	1.2	0.6	0.54
110569		2.6	18	0.24	< 0.056	< 0.058	3.2	< 0.13	0.1	0.3	1.3	0.12	0.14	< 0.049	0.7	21	0.57	0.98	0.52	0.44
	Average*	2.8	18.2	0.3	0.0	0.0	3.5	0.2	0.1	0.3	1.4	0.1	0.1	0.0	0.7	22.2	0.6	1.1	0.6	0.5
	Std. Dev.	0.2	0.6	0.1	0.0	0.0	0.3	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	1.1	0.0	0.1	0.0	0.0
	R.S.D.	7.2%	3.1%	21.7%	?	?	7.4%	100.0%	4.9%	9.6%	5.4%	13.1%	5.3%	100.0%	2.5%	5.1%	1.4%	9.9%	7.3%	10.0%
Exposure Group NQSE																				
110584		< 0.079	0.33	< 0.098	< 0.13	< 0.11	0.69	0.61	0.13	0.43	1.3	0.27	0.16	< 0.091	< 0.75	23	< 0.57	1.3	0.61	0.54
110601		< 0.023	0.41	0.031	< 0.037	< 0.032	0.65	0.57	0.12	0.44	1.4	0.21	0.15	0.073	0.61	35	0.56	1.5	0.64	0.47
	Average*	0.0	0.4	0.0	0.0	0.0	0.7	0.6	0.1	0.4	1.3	0.2	0.2	0.0	0.3	29.1	0.3	1.4	0.6	0.5
	Std. Dev.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	5.9	0.3	0.1	0.0	0.0
	R.S.D.	?	10.4%	100.0%	?	?	3.1%	2.8%	5.0%	0.6%	3.4%	13.0%	2.7%	100.0%	100.0%	20.4%	100.0%	7.3%	2.4%	6.3%
Exposure Group PCBS																				
110572		< 0.043	0.36	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
110620		< 0.061	0.35	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	Average*	0.0	0.4																	
	Std. Dev.	0.0	0.0																	
	R.S.D.	?	2.6%																	

HCB = hexachlorobenzene; Lind = lindane; Hept = heptachlor; HPE = heptachlorepoxide; Oxy-Chlor = oxychlordane; γ - Chlor = gamma-chlordane; α - Chlor = alpha-chlordane; t - Nona = trans-nonachlor; c - Nona = cis-nonachlor.

NR Samples in the PCB and HCBD exposure groups were not analyzed for pesticides other than HCB and HCBD. NR is reported in place of concentrations for pesticides that were not analyzed in these samples.

* When an analyte was detected in some, but not all of the samples, the average concentration is based on the concentration when detected and zero when not detected. When an analyte was not detected in any of the samples, zero is reported for the average and the Std. Dev. and a "?" is reported for the R.S.D.

Table 11-p1: Concentrations (ng/g, wet weight) of chlorobiphenyl congeners (by IUPAC number) in tissues analyzed in replicate as part of the 1997 Hylebos Salmon Exposure/Growth Study.

Sample #	18	28	44	52	66	101¥	105	118	128	138¥	153¥	170	180¯	187	195	206	209	PCBs (Est. Total)
Exposure Group	**HCBD**																	
110-551	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0
110-553	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0
Average*																		0
Std. Dev.																		0.00
R.S.D.																		?
Exposure Group	**HWSE-M**																	
110-558	0.32	0.32	0.49	0.86	0.53	1.8	0.4	1.4	0.34	2.9	3.7	0.42	0.66	1.1	0.37	2.2	5.3	46
110-622	0.58	0.29	0.69	0.91	0.48	2	0.39	1.4	0.33	2.8	3.5	0.45	0.55	1	0.36	2	5.1	46
Average*	0.45	0.31	0.59	0.88	0.50	1.89	0.40	1.39	0.34	2.88	3.59	0.43	0.60	1.06	0.37	2.13	5.22	46
Std. Dev.	0.13	0.01	0.10	0.03	0.02	0.07	0.00	0.02	0.01	0.08	0.11	0.02	0.05	0.02	0.00	0.09	0.11	0.25
R.S.D.	29.7%	4.8%	17.4%	2.9%	4.8%	3.5%	1.1%	1.6%	2.3%	2.2%	3.0%	3.5%	9.1%	1.8%	0.9%	4.0%	2.0%	0.5%
Exposure Group	**HWSE-P**																	
110-560	0.3	0.28	0.44	0.95	0.55	2.1	0.44	1.5	0.38	3.3	3.9	0.43	0.62	1.1	0.41	2.5	6.2	51
110-569	0.21	0.21	0.48	0.86	0.31	1.9	0.38	1.4	0.35	3.2	3.7	0.4	0.61	1.1	0.4	2.5	6	48
Average*	0.25	0.24	0.46	0.90	0.43	1.99	0.41	1.49	0.36	3.27	3.78	0.42	0.61	1.09	0.41	2.50	6.09	49
Std. Dev.	0.04	0.03	0.02	0.04	0.12	0.10	0.03	0.06	0.01	0.07	0.09	0.01	0.00	0.02	0.01	0.04	0.09	1.50
R.S.D.	16.9%	12.4%	4.4%	4.5%	27.1%	5.1%	8.1%	3.9%	3.7%	2.2%	2.5%	3.5%	0.7%	1.8%	1.5%	1.7%	1.4%	3.0%
Exposure Group	**NQSE**																	
110-584	< 0.29	0.25	0.46	0.82	0.25	1.9	0.38	1.3	0.32	2.4	3.2	0.25	0.41	0.78	< 0.062	< 0.064	< 0.074	26
110-601	0.3	0.22	0.48	0.85	0.42	2	0.37	1.4	0.33	2.8	3.5	0.25	0.52	0.79	0.051	0.05	< 0.022	29
Average*	0.15	0.24	0.47	0.84	0.34	1.96	0.38	1.40	0.33	2.59	3.36	0.25	0.47	0.79	0.03	0.03	0.00	27
Std. Dev.	0.15	0.02	0.01	0.02	0.09	0.01	0.00	0.05	0.00	0.19	0.11	0.00	0.06	0.01	0.03	0.03	0.00	1.43
R.S.D.	100.0%	6.8%	2.0%	1.8%	25.4%	0.5%	1.0%	3.8%	0.9%	7.3%	3.3%	0.6%	12.0%	0.7%	100.0%	100.0%	?	5.3%
Exposure Group	**PCBS**																	
110-572	3.9	8.8	270Δ	610Δ	200Δ	980Δ	400Δ	710Δ	360Δ	910Δ	840Δ	150Δ	140Δ	43	2.7	1.1	0.23	11000
110-620	4	8.9	300Δ	670Δ	190Δ	1100Δ	440Δ	800Δ	390Δ	1000Δ	940Δ	150Δ	160Δ	44	2.5	1	0.22	12000
Average*	3.98	8.82	283.63	639.83	192.25	1031.22	421.34	755.08	376.43	952.62	889.94	147.93	148.18	43.60	2.58	1.07	0.22	11797
Std. Dev.	0.04	0.05	11.88	30.48	3.82	51.75	16.67	40.44	16.06	47.54	51.12	0.45	12.82	0.22	0.08	0.04	0.01	549.37
R.S.D.	1.0%	0.5%	4.2%	4.8%	2.0%	5.0%	4.0%	5.4%	4.3%	5.0%	5.7%	0.3%	8.7%	0.5%	3.0%	3.9%	2.9%	4.7%

Δ Concentrations of these analytes were estimated because they exceeded the GC-ECD calibration range.

NR Samples in the HCBD exposure group were not analyzed for PCBs. NR is reported in place of concentrations of congeners that were not analyzed in these samples.

¥PCBs 101 and 90 are not resolved by our gas chromatographic procedure, therefore we report their combined concentrations as "101".
PCBs 138, 163, and 164 are not resolved by our gas chromatographic procedure, therefore we report their combined concentrations as "138".
PCBs 153 and 132 are not resolved by our gas chromatographic procedure, therefore we report their combined concentrations as "153".

¯ PCB180 coelutes with an unidentified compound and its concentration s estimated based on a percentage determined by GC/MS.

PCBs (Est. Total) is an estimate of the total PCBs obtained by multiplying the sum of the concentrations of the 17 individual congeners reported here by 2.

* When an analyte was detected in some, but not all of the samples, the average concentration is based on the concentration when detected and zero when not detected. When an analyte was not detected in any of the samples, zero is reported for the average and the Std. Dev., and a "?" is reported for the R.S.D.

Table 1J-p1. Continuing calibration verification data* (based on % recoveries) for chlorinated pesticides in standards run before, during and after the samples analyzed as part of the 1997 Hylebos Salmon Growth Study and the 1997 Puget Sound Salmon Study.

	HCB	LIND	HEPT	Aldrin	HPE	OXY	γ-Chlor	α-Chlor	t-Nona	DIEL	c-Nona	Mirex	o,p'-DDE	p,p'-DDE	o,p'-DDD	p,p'-DDD	o,p'-DDT	p,p'-DDT
H506																		
H506CH5E3A	93	93	100	93	93	93	93	93	93	93	93	93	93	93	93	93	93	93
H506CH5E3B	99	102	127	101	101	102	101	101	101	101	102	102	100	101	102	103	106	110
H506CH5E3C	102	104	126	103	105	103	104	104	104	104	104	105	103	103	104	105	109	112
H506CH5E3D	100	101	115	101	102	101	101	101	101	101	102	102	101	101	102	101	105	106
Average	98	100	117	100	100	100	100	100	100	100	100	100	99	99	100	101	103	105
Standard Deviation	3.4	4.2	11.1	3.9	4.5	4.0	4.0	3.9	4.1	4.0	4.3	4.4	3.7	3.9	4.3	4.6	6.1	7.5
Relative Standard Deviation	3.4%	4.2%	9.5%	3.9%	4.5%	4.0%	4.0%	3.9%	4.1%	4.0%	4.3%	4.4%	3.7%	3.9%	4.3%	4.6%	5.9%	7.1%
H507																		
H507CH5E3A	92	93	96	98	94	93	93	95	93	95	92	92	94	98	93	95	92	90
H507CH5E3B	100	104	116	105	104	103	102	103	103	103	102	104	102	104	103	107	109	110
H507CH5E3C	103	109	123	108	106	109	107	107	107	108	107	108	105	107	107	113	115	118
H507CH5E3D	101	105	117	106	107	105	105	105	105	106	105	106	104	107	106	109	111	113
H507CH5E3E	101	102	111	103	102	104	102	102	102	102	102	105	101	102	103	102	107	107
Average	99	103	112	104	103	103	102	102	102	103	102	103	101	104	102	105	107	108
Standard Deviation	3.7	5.3	9.2	3.5	4.7	5.3	4.6	4.1	4.7	4.5	5.2	5.4	3.8	3.4	4.9	6.0	7.9	9.3
Relative Standard Deviation	3.7%	5.1%	8.2%	3.4%	4.6%	5.2%	4.6%	4.0%	4.6%	4.4%	5.1%	5.3%	3.7%	3.3%	4.8%	5.8%	7.4%	8.6%
H508																		
H508CH5E3A	88	88	90	93	89	88	89	90	89	90	87	88	90	93	89	90	87	85
H508CH5E3B	100	106	121	106	104	105	103	104	104	105	105	104	102	104	104	110	112	115
H508CH5E3C	103	108	125	106	105	108	105	105	106	106	107	108	103	105	105	109	115	119
H508CH5E3D	101	102	115	103	104	103	102	102	103	102	102	105	101	103	103	105	109	110
Average	98	101	113	102	101	101	100	100	100	101	100	101	99	101	100	104	105	107
Standard Deviation	5.9	7.6	13.6	5.3	6.6	7.7	6.5	6.0	6.7	6.3	7.6	8.0	5.4	4.8	6.7	7.9	11.1	13.0
Relative Standard Deviation	6.0%	7.5%	12.0%	5.2%	6.6%	7.7%	6.5%	6.0%	6.7%	6.2%	7.6%	7.9%	5.4%	4.7%	6.7%	7.7%	10.5%	12.1%
H509																		
H509CH5E3A	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H509CH5E3B	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H509CH5E3C	102	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H509CH5E3D	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standard Deviation	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Relative Standard Deviation	1.1%	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?

HCB = hexachlorobenzene; LIND = lindane; HEPT = heptachlor; HPE = heptachlor epoxide; OXY = oxychlordane; γ-Chlor = gamma-chlordane; α-Chlor = alpha-chlordane; Nona 3 = nonachlor III; t-Nona = trans-nonachlor; c-Nona = cis-nonachlor.

* Data are reported as percent recovery calculated using the multilevel curve generated for each set.

H509 was processed for HCB/HCBD only; calibration data for HCB are reported, but not for other pesticides.

Final

Table 16 p2. Continuing calibration verification data[a] (based on % recoveries) for chlorinated pesticides in standards run before, during and after the samples analyzed as part of the 1997 Hylebos Salmon Growth Study and the 1997 Puget Sound Salmon Study.

	HCB	LIND	HEPT	Aldrin	HPE	OXY	γ-Chlor	α-Chlor	t-Nona	DIEL	c-Nona	Mirex	o,p'-DDE	p,p'-DDE	o,p'-DDD	p,p'-DDD	o,p'-DDT	p,p'-DDT
H510																		
H510CH5E3B	100	102	106	108	102	101	101	103	102	103	100	101	103	106	102	105	10?	101
H510CH5E3C	100	100	106	103	101	101	101	101	101	101	99	101	101	104	101	103	10	101
H510CH5E3D	95	92	96	97	95	96	95	96	95	95	93	96	96	98	95	95	9	91
H510CH5E3E	92	91	93	95	94	93	94	94	93	94	93	94	94	96	94	92	9	90
Average	97	96	100	100	98	98	98	99	98	98	96	98	98	101	98	99	9	96
Standard Deviation	3.3	4.8	5.8	4.8	3.4	3.7	3.3	3.7	3.5	4.0	3.3	3.2	3.6	3.9	3.6	5.7	4.	5.5
Relative Standard Deviation	3.4%	5.0%	5.8%	4.5%	3.5%	3.8%	3.4%	3.8%	3.5%	4.1%	3.4%	3.2%	3.7%	3.8%	3.6%	5.8%	4.2%	5.7%
H511																		
H511CH5E3A	99	100	104	105	101	100	101	102	101	102	99	100	102	105	101	104	10	100
H511CH5E3B	100	101	107	103	102	100	100	101	101	101	100	100	101	103	101	102	101	101
H511CH5E3C	100	100	107	102	103	98	101	101	101	101	101	101	101	103	101	102	101	101
H511CH5E3D	98	98	104	100	100	98	99	99	99	99	98	99	99	101	99	99	99	98
Average	99	100	105	103	101	99	100	101	100	101	100	100	101	103	100	102	10	100
Standard Deviation	0.9	1.2	1.4	1.8	1.2	0.9	0.8	1.0	0.8	1.0	0.9	0.8	1.0	1.7	0.8	1.7	1.0	1.2
Relative Standard Deviation	0.9%	1.2%	1.3%	1.7%	1.2%	0.9%	0.8%	1.0%	0.7%	1.0%	0.9%	0.8%	1.0%	1.6%	0.8%	1.7%	1.0%	1.2%
H512																		
H512CH5E3A	91	91	94	96	92	91	92	93	92	93	91	91	93	96	92	93	90	89
H512CH5E3B	100	106	116	105	103	104	102	103	103	103	103	104	101	104	104	108	108	110
H512CH5E3C	102	107	120	106	106	107	105	105	106	106	107	107	104	106	107	107	111	113
H512CH5E3D	102	107	120	107	108	107	106	106	107	107	107	107	105	107	108	110	112	113
Average	99	103	112	104	102	102	101	102	102	102	102	102	101	103	102	105	105	106
Standard Deviation	4.7	6.7	11.0	4.4	6.0	6.3	5.7	5.2	6.0	5.4	6.7	8.9	4.7	4.3	6.4	6.7	8.9	10.0
Relative Standard Deviation	4.8%	6.5%	9.8%	4.2%	5.8%	6.2%	5.7%	5.1%	5.9%	5.2%	6.6%	8.8%	4.6%	4.1%	6.3%	6.4%	8.4%	9.4%
H513																		
H513CH5E3A	98	100	103	105	101	99	100	101	100	101	98	100	101	105	100	103	100	99
H513CH5E3B	100	102	108	104	100	102	101	102	101	102	100	100	101	103	101	105	101	102
H513CH5E3C	101	100	108	102	99	104	101	102	102	101	102	105	102	103	102	102	104	103
Average	100	100	106	104	100	102	100	102	101	102	100	102	101	104	101	103	102	101
Standard Deviation	1.3	0.9	2.1	1.2	0.7	1.7	0.6	0.2	0.8	0.2	1.6	2.4	0.3	0.6	0.9	1.1	1.6	1.7
Relative Standard Deviation	1.3%	0.9%	1.9%	1.1%	0.7%	1.7%	0.6%	0.2%	0.8%	0.2%	1.6%	2.3%	0.3%	0.6%	0.9%	1.1%	1.6%	1.7%
H515																		
H515CH5E3A	99	101	104	108	102	101	101	102	101	103	99	102	102	105	101	103	100	98

HCB = hexachlorobenzene; LIND = lindane; HEPT = heptachlor; HPE = heptachlor epoxide; OXY = oxychlordane; γ-Chlor = gamma-chlordane; α-Chlor = alpha-chlordane; Nona 3 = nonachlor III; t-Nona = trans-nonachlor; c-Nona = cis-nonachlor.

[a] Data are reported as percent recovery calculated using the multilevel curve generated for each set.

H509 was processed for HCB/HCBD only; calibration data for HCB are reported, but not for other pesticides

Table 1J-p3: Continuing calibration verification data* (based on % recoveries) for chlorinated pesticides in standards run before, during and after the samples analyzed as part of the 1997 Hylebos Salmon Growth Study and the 1997 Puget Sound Salmon Study.

	HCB	LIND	HEPT	Aldrin	HPE	OXY	γ-Chlor	α-Chlor	t-Nona	DIEL	c-Nona	Mirex	o,p'-DDE	p,p'-DDE	o,p'-DDD	p,p'-DDD	o,p'-DDT	p,p'-DDT
H515CHSE3B	100	103	108	103	101	101	100	101	101	101	100	101	101	103	101	104	101	101
H515CHSE3C	97	94	98	98	96	96	96	97	95	96	94	85	97	98	95	95	93	92
Average	99	99	103	102	100	99	99	100	99	100	97	99	100	102	99	101	98	97
Standard Deviation	1.8	3.8	4.4	3.3	2.7	2.5	2.1	2.4	2.5	2.8	2.7	3.3	2.1	3.2	2.8	4.2	3.4	3.9
Relative Standard Deviation	1.8%	3.8%	4.2%	3.2%	2.8%	2.5%	2.2%	2.4%	2.6%	2.8%	2.8%	3.3%	2.1%	3.1%	2.8%	4.2%	3.5%	4.1%

HCB = hexachlorobenzene; LIND = lindane; HEPT = heptachlor; HPE = heptachlor epoxide; OXY = oxychlordane; γ-Chlor = gamma-chlordane; α-Chlor = alpha-chlordane; Nona 3 = nonachlor III; t-Nona = trans-nonachlor; c-Nona = cis-nonachlor.

* Data are reported as percent recovery calculated using the multilevel curve generated for each set.

H509 was processed for HCB/HCBD only; calibration data for HCB are reported, but not for other pesticides.

Table 1K-p1: Continuing calibration verification data[1] (based on % recoveries) for chlorinated biphenyl congeners (by IUPAC number) in standards run before, during and after the samples analyzed as part of the 1997 Hylebos Salmon Growth Study and the 1997 Puget Sound Salmon Study.

	18	28	44	52	66	101	105	118	128	138	153	170	180	187	195	206	209
H506																	
H506CH5E3A	93	93	93	93	93	93	93	93	93	93	93	93	93	93	93	93	93
H506CH5E3B	99	100	100	99	100	100	100	99	100	100	100	100	100	100	100	100	100
H506CH5E3C	102	103	102	102	103	102	102	103	103	103	103	103	103	103	103	104	103
H506CH5E3D	100	100	100	100	100	100	101	100	100	100	98	100	100	100	100	100	100
Average	98	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
Standard Deviation	3.3	3.5	3.5	3.3	3.5	3.4	3.6	3.7	3.6	3.5	3.8	3.7	3.6	3.5	3.7	3.8	3.6
Relative Standard Deviation	3.3%	3.6%	3.5%	3.4%	3.6%	3.5%	3.6%	3.7%	3.7%	3.5%	3.8%	3.7%	3.6%	3.5%	3.7%	3.9%	3.7%
H507																	
H507CH5E3A	92	94	94	92	94	93	94	94	94	93	93	93	93	93	93	92	92
H507CH5E3B	99	101	101	99	101	100	102	101	101	100	100	101	101	100	101	101	101
H507CH5E3C	102	104	104	103	105	103	107	105	105	104	102	104	104	104	104	104	104
H507CH5E3D	100	102	102	101	102	101	103	102	102	102	101	102	102	102	101	101	101
H507CH5E3E	101	99	101	100	99	100	100	98	100	100	100	100	100	101	100	100	101
Average	99	100	100	99	100	99	101	100	100	100	99	100	100	100	100	100	100
Standard Deviation	3.7	3.5	3.2	3.9	3.7	3.6	4.2	3.7	3.6	3.7	3.2	3.8	3.7	3.6	3.9	4.1	4.0
Relative Standard Deviation	3.8%	3.5%	3.2%	3.9%	3.7%	3.6%	4.1%	3.7%	3.6%	3.7%	3.3%	3.8%	3.7%	3.6%	3.9%	4.1%	4.0%
H508																	
H508CH5E3A	87	89	90	87	89	88	89	89	89	88	88	88	89	89	88	88	88
H508CH5E3B	99	102	101	99	101	100	103	101	101	100	99	101	101	100	101	100	100
H508CH5E3C	103	104	104	103	104	103	105	105	105	104	104	105	105	104	105	105	105
H508CH5E3D	101	101	102	100	101	101	102	102	101	101	99	101	101	101	101	101	101
Average	97	99	99	97	99	96	100	99	99	98	98	99	99	98	99	99	98
Standard Deviation	5.9	5.6	5.4	6.0	5.8	5.8	6.0	6.0	5.8	5.9	5.8	6.3	6.1	5.8	6.4	6.6	6.5
Relative Standard Deviation	6.1%	5.7%	5.5%	6.2%	5.9%	6.0%	6.0%	6.0%	5.8%	6.0%	5.9%	6.4%	6.1%	5.9%	6.5%	6.7%	6.6%
H509																	
H509CH5E3A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H509CH5E3B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H509CH5E3C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H509CH5E3D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standard Deviation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Relative Standard Deviation	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
H510																	
H510CH5E3B	100	102	102	99	101	100	102	102	102	101	101	101	101	101	101	101	100
H510CH5E3C	99	100	101	99	100	100	102	100	101	100	98	100	100	100	100	100	100
H510CH5E3D	95	95	96	95	95	95	95	95	95	95	94	95	95	95	95	95	95

[1]Data are reported as percent recovery calculated using the multilevel curve generated for each set

H509 was processed for HCB/HCBD only; calibration data for HCB are repored, but not for PCBs

Table 1K-p2. Continuing calibration verification data* (based on % recovery) for chlorinated biphenyl congeners (by IUPAC number) in standards run before, during and after the samples analyzed as part of the 1997 Hylebos Salmon Growth Study and the 1997 Puget Sound Salmon Study.

	18	28	44	52	66	101	105	118	128	138	153	170	180	187	195	206	209
H510CH6E3E	92	93	93	92	92	93	91	92	93	92	93	92	92	93	93	92	93
Average	97	97	98	97	97	97	98	97	98	97	97	97	97	97	97	97	97
Standard Deviation	3.0	3.8	3.6	3.0	3.9	3.2	4.5	4.1	3.9	3.5	3.2	3.8	3.7	3.3	3.5	3.5	3.2
Relative Standard Deviation	3.1%	3.9%	3.7%	3.1%	4.0%	3.3%	4.6%	4.2%	4.0%	3.6%	3.3%	3.9%	3.8%	3.4%	3.6%	3.6%	3.4%
H511																	
H511CH6E3A	99	101	101	98	100	100	101	101	101	100	100	100	100	100	100	100	99
H511CH6E3B	100	101	101	100	100	100	100	101	101	100	101	100	100	100	100	100	100
H511CH6E3C	99	100	101	100	100	100	101	101	101	100	101	100	100	100	100	100	100
H511CH6E3D	98	98	99	98	98	98	98	98	98	98	98	98	98	98	98	98	98
Average	99	100	101	99	100	100	100	100	100	99	100	100	100	100	100	99	99
Standard Deviation	0.7	1.1	1.1	0.7	1.0	0.8	1.1	1.0	1.0	0.8	1.1	0.8	0.9	0.8	0.9	0.8	0.8
Relative Standard Deviation	0.7%	1.1%	1.1%	0.7%	1.0%	0.8%	1.1%	1.0%	1.0%	0.8%	1.1%	0.8%	0.9%	0.8%	0.9%	0.8%	0.8%
H512																	
H512CH6E3A	90	92	93	90	92	91	93	92	92	91	91	91	92	91	91	91	90
H512CH6E3B	99	101	101	99	101	100	102	100	101	101	100	101	101	100	101	101	100
H512CH6E3C	102	103	103	102	103	103	102	103	104	103	106	104	104	103	104	104	103
H512CH6E3D	102	103	104	102	103	103	104	103	104	104	104	104	104	104	104	103	103
Average	98	100	100	98	100	99	100	100	100	100	100	100	100	100	100	100	99
Standard Deviation	4.9	4.8	4.4	5.0	4.8	4.9	4.4	4.6	4.8	5.0	5.7	5.2	5.0	4.9	5.2	5.2	5.3
Relative Standard Deviation	5.0%	4.6%	4.3%	5.1%	4.8%	4.9%	4.4%	4.6%	4.8%	5.0%	5.7%	5.2%	5.0%	5.0%	5.2%	5.3%	5.3%
H513																	
H513CH6E3A	97	100	100	97	99	98	100	100	100	99	99	99	99	99	99	98	98
H513CH6E3B	100	101	101	99	101	100	102	101	101	100	99	100	100	100	100	99	99
H513CH6E3C	102	101	102	101	102	103	102	104	104	104	105	105	105	104	105	106	105
Average	100	101	101	99	101	100	102	102	102	101	101	101	101	101	101	101	101
Standard Deviation	1.8	0.8	0.7	1.6	1.0	1.7	1.0	1.9	1.8	2.0	3.1	2.6	2.4	2.3	2.9	3.2	3.1
Relative Standard Deviation	1.8%	0.6%	0.7%	1.6%	1.0%	1.7%	1.0%	1.9%	1.8%	2.0%	3.1%	2.6%	2.3%	2.3%	2.9%	3.1%	3.1%
H515																	
H515CH6E3A	98	100	101	98	100	99	101	101	101	100	100	100	100	100	100	100	99
H515CH6E3B	99	101	100	99	100	99	101	100	100	100	99	100	100	99	100	99	99
H515CH6E3C	97	97	98	97	97	97	97	97	97	96	96	96	97	97	96	96	96
Average	98	99	100	98	99	98	100	99	99	99	98	99	99	99	99	98	98
Standard Deviation	0.7	1.5	1.5	0.8	1.5	1.1	1.7	1.7	1.9	1.5	1.7	1.8	1.6	1.4	1.6	1.6	1.4
Relative Standard Deviation	0.7%	1.5%	1.5%	0.8%	1.5%	1.2%	1.7%	1.8%	1.9%	1.6%	1.7%	1.9%	1.6%	1.5%	1.5%	1.6%	1.4%

*Data are reported as percent recovery calculated using the multilevel curve generated for each set.

H509 was processed for HCB/HCBD only; calibration data for HCB are reported, but not for PCBs.

Table 1L-p1: Standard curve correlation (r) from the 2nd order regression of the amount ratio of the analyte (versus the internal standard) to the area response ratio (versus the internal standard) for the multilevel standards.

Analyte	H506 r	H507 r	H508 r	H509* r	H510 r	H511 r	H512 r	H513 r	H515 r
hexachlorobenzene	0.9999	1.0000	1.0000	1.0000	1.0000	0.9999	1.0000	1.0000	1.0000
lindane	0.9995	0.9997	0.9997		0.9998	1.0000	0.9997	0.9999	0.9998
3\18	0.9999	1.0000	1.0000		1.0000	0.9999	1.0000	1.0000	1.0000
3\28	1.0000	0.9998	0.9998		0.9999	0.9998	0.9999	0.9999	0.9999
heptachlor	0.9922	0.9991	0.9986		0.9998	1.0000	0.9989	0.9999	0.9998
4\52	0.9999	1.0000	1.0000		1.0000	0.9995	1.0000	1.0000	1.0000
aldrin	0.9998	0.9993	0.9994		0.9995	0.9998	0.9994	0.9994	0.9994
4\44	0.9999	0.9997	0.9997		0.9998	0.9998	0.9998	0.9998	0.9998
HPE	0.9992	0.9997	0.9998		0.9998	0.9999	0.9998	0.9998	0.9998
oxychlordane	0.9995	0.9997	0.9998		0.9999	0.9999	0.9998	0.9999	0.9998
4\66	1.0000	0.9999	0.9999		0.9999	0.9999	0.9999	0.9999	0.9999
gamma-chlordane	0.9998	0.9998	0.9998		0.9999	0.9998	0.9998	0.9999	0.9998
o,p'-DDE	1.0000	0.9998	0.9998		0.9998	1.0000	0.9998	0.9998	0.9998
5\101	0.9999	0.9996	1.0000		1.0000	0.9998	1.0000	1.0000	1.0000
alpha-chlordane	0.9998	0.9997	0.9998		0.9998	0.9999	0.9998	0.9998	0.9997
trans-nonachlor	0.9997	0.9998	0.9998		0.9999	0.9998	0.9999	0.9999	0.9999
dieldrin	0.9997	0.9997	0.9997		0.9998	0.9994	0.9998	0.9998	0.9997
p,p'-DDE	0.9998	0.9993	0.9993		0.9994	0.9999	0.9994	0.9993	0.9994
o,p'-DDD	0.9995	0.9998	0.9998		0.9999	0.9999	0.9998	0.9999	0.9999
5\118	0.9999	0.9998	0.9998		0.9999	1.0000	0.9999	0.9998	0.9999
cis-nona	0.9993	1.0000	0.9998		0.9999	0.9996	0.9998	0.9999	0.9999
p,p'-DDD	0.9978	0.9994	0.9995		0.9996	0.9999	0.9995	0.9996	0.9997
o,p'-DDT	0.9939	0.9991	0.9990		0.9999	1.0000	0.9994	0.9999	0.9999
6\153	0.9997	0.9999	0.9999		0.9999	0.9998	0.9999	0.9998	0.9999
5\105	1.0000	0.9997	0.9998		0.9998	1.0000	0.9998	0.9998	0.9999
p,p'-DDT	0.9857	0.9990	0.9987		0.9999	1.0000	0.9992	0.9999	0.9999
6\138	1.0000	0.9999	0.9999		0.9999	1.0000	0.9999	0.9999	0.9999
7\187	1.0000	0.9999	0.9999		0.9999	0.9999	1.0000	0.9999	1.0000
6\128	0.9999	0.9998	0.9998		0.9998	0.9999	0.9998	0.9998	0.9998
7\180	1.0000	0.9999	0.9999		0.9999	1.0000	0.9999	0.9999	0.9999
mirex	0.9994	0.9997	0.9998		0.9999	0.9999	0.9998	0.9999	0.9998
7\170	0.9999	0.9999	0.9999		0.9999	0.9999	0.9999	0.9998	0.9999
8\195	0.9995	0.9999	0.9999		1.0000	1.0000	0.9999	0.9998	0.9999
9\206	0.9999	1.0000	1.0000		1.0000	1.0000	1.0000	0.9998	1.0000
10\209	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	0.9999	1.0000

Based on six concentration levels of standards, except H506, which is based on five levels of standards.
*** H509 was analyzed for HCB and HCBD only.**

Table 1M-p1: Concentrations of analytes in 7 replicates of spiked clean tissue and calculated method detection limits (MDL, ng/g, wet weight) for pesticides, DDTs and chlorobiphenyl congeners calculated by the method in appendix B of 40CFR part 136 (sample set H376 spiked at low level, 5/96).

Sample#	HCB	LIND	HEPT	Aldrin	HPE	alpha chlordane	gamma chlordane	t-NONA	Dieldrin	Mirex	o,p'-DDE	p,p'-DDE
110-471	1.4	0.85	1.1	0.56	0.89	1	0.97	1.4	0.76	1	0.79	1.8
110-472	1	0.71	0.98	0.5	0.74	0.75	0.8	0.95	0.62	0.9	0.75	1
110-473	1.2	0.75	0.98	0.51	0.77	0.82	0.83	1.1	0.66	0.9	0.74	1.2
110-474	1.2	0.81	1.1	0.55	0.84	0.88	0.91	1.2	0.73	1	0.79	1.4
110-475	1.2	0.81	1	0.56	0.83	0.86	0.93	1.1	0.73	1	0.82	1.3
110-476	1.1	0.76	0.95	0.52	0.76	0.77	0.84	1	0.67	0.9	0.75	1.1
110-477	1.1	0.75	0.94	0.52	0.77	0.79	0.83	1	0.66	0.98	0.77	1.2
Average	1.2	0.8	1.0	0.5	0.8	0.8	0.9	1.1	0.7	1.0	0.8	1.3
Std Dev	0.13	0.05	0.07	0.02	0.05	0.09	0.06	0.15	0.05	0.05	0.03	0.26
MDL	0.39	0.15	0.21	0.08	0.17	0.27	0.20	0.48	0.16	0.16	0.09	0.82

Sample#	o,p'-DDD	p,p'-DDD	o,p'-DDT	p,p'-DDT	3\18	3\28	4\44	4\52	4\66	5\101	5\105	5\118	6\128	6\138
110-471	1.1	1.3	1.6	1.4	1.6	1.7	2	1.9	1.4	2	0.95	1.3	0.95	1.7
110-472	0.95	0.99	1.1	1	1.4	1.4	1.8	1.6	1.2	1.5	0.9	1.1	0.86	1.3
110-473	0.98	1.1	1.2	1.1	1.4	1.5	1.8	1.7	1.2	1.6	0.85	1.1	0.87	1.4
110-474	1.1	1.2	1.4	1.2	1.5	1.6	2.1	1.9	1.4	1.8	1.1	1.2	0.98	1.6
110-475	1.1	1.1	1.3	1.2	1.6	1.6	2	1.9	1.4	1.7	1	1.2	0.99	1.5
110-476	0.96	1	1.2	1.1	1.4	1.5	1.9	1.7	1.3	1.6	0.92	1.1	0.91	1.4
110-477	1	1.1	1.2	1.1	1.5	1.5	1.9	1.8	1.3	1.7	0.98	1.2	0.94	1.5
Average	1.0	1.1	1.3	1.2	1.5	1.5	1.9	1.8	1.3	1.7	1.0	1.2	0.9	1.5
Std Dev	0.07	0.11	0.17	0.13	0.09	0.10	0.11	0.12	0.09	0.16	0.08	0.08	0.05	0.13
MDL	0.22	0.34	0.53	0.40	0.28	0.31	0.35	0.38	0.28	0.51	0.25	0.24	0.16	0.42

Sample#	6\153	7\170	7\180	7\187	8\195	9\206	10\209
110-471	1.9	2.3	0.99	1.1	0.8	0.78	0.82
110-472	1.4	2	0.85	1	0.77	0.75	0.79
110-473	1.6	2.5	0.88	1	0.76	0.74	0.79
110-474	1.7	3.5	0.99	1.1	0.84	0.86	0.89
110-475	1.8	2.5	0.99	1.2	0.89	0.87	0.91
110-476	1.6	2.2	0.9	1	0.78	0.81	0.83
110-477	1.7	2	0.94	1.1	0.83	0.81	0.86
Average	1.7	2.4	0.9	1.1	0.8	0.8	0.8
Std Dev	0.16	0.52	0.06	0.08	0.05	0.05	0.05
MDL	0.50	1.62	0.18	0.24	0.15	0.16	0.15

Sample#	HCBD
110-471RH	0.93
110-472RH	0.87
110-473RH	0.86
110-474RH	0.86
110-475RH	0.97
110-476RH	0.91
110-477RH	0.96
Average	0.9
Std Dev	0.05
MDL	0.15

HCB = Hexachlorobenzene, HCBD = Hexachlorobutadiene, LIND = Lindane, HEPT = Heptachlor.

ANOVA Output: Treatment Effects (SuperANOVA. Abacus Concepts Inc., Berkeley. CA).
Hepatic PCB levels from biomarkert study samples (6, 20 d post exposure) and growth study samples (60 d post exposure).

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treatment	5	6.715E8	1.343E8	1.587E3	.0001
Time	2	84216513.402	4.211E7	4.98E2	.0001
Treatment * Time	10	3.829E8	3.829E7	4.52E2	.0001
Residual	24	2031151.250	84631.302		

Dependent: total_PCB_conc

Means Table
Effect: Treatment * Time
Dependent: total_PCB_conc

	Count	Mean	Std. Dev.	Std. Error
NONE, 0 day	4	81.750	10.874	5.437
Ace/Emulphor, 06 days	2	72.000	5.657	4.000
Ace/Emulphor, 20 days	2	58.000	8.485	6.000
Ace/Emulphor, 60 days	2	16.000	2.828	2.000
HCBD, 06 days	2	0.000	0.000	0.000
HCBD, 20 days	2	0.000	0.000	0.000
HCBD, 60 days	4	8.500	9.950	4.975
HWSE-M, 06 days	2	170.000	14.142	10.000
HWSE-M, 20 days	2	55.500	.707	.500
HWSE-M, 60 days	2	17.000	1.414	1.000
HWSE-P, 06 days	2	165.000	7.071	5.000
HWSE-P, 20 days	2	81.000	7.071	5.000
HWSE-P, 60 days	2	19.000	2.828	2.000
NQSE, 06 days	2	71.000	8.485	6.000
NQSE, 20 days	2	42.500	2.121	1.500
NQSE, 60 days	2	14.500	.707	.500
PCBs, 06 days	1	23000.000	0.000	0.000
PCBs, 20 days	2	13000.000	1414.214	1000.000
PCBs, 60 days	4	1150.000	100.000	50.000

from both biomarker and growth studies

ANOVA Output: Treatment Effects (SuperANOVA, Abacus Concepts Inc., Berkeley, CA).
Whole body PCB levels from biomarkert study samples (6, 20 d post exposure) and growth study samples (60 d post exposure).

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treatment	5	4.438E8	8.875E7	1.896E3	.0001
Time	2	17708903.714	8854451.857	1.89E2	.0001
Treatment * Time	10	60509456.581	6050945.658	1.29E2	.0001
Residual	25	1170003.167	46800.127		

Dependent: total_PCB_conc

Means Table
Effect: Treatment * Time
Dependent: total_PCB_conc

	Count	Mean	Std. Dev.	Std. Error
NONE, 0 day	4	35.500	11.091	5.545
Ace/Emulphor, 06 days	2	28.000	2.828	2.000
Ace/Emulphor, 20 days	2	26.000	0.000	0.000
Ace/Emulphor, 60 days	2	34.000	8.485	6.000
HCBD, 06 days	2	0.000	0.000	0.000
HCBD, 20 days	2	0.000	0.000	0.000
HCBD, 60 days	3	50.000	37.323	21.548
HWSE-M, 06 days	2	46.000	0.000	0.000
HWSE-M, 20 days	2	40.000	2.828	2.000
HWSE-M, 60 days	3	37.333	3.512	2.028
HWSE-P, 06 days	3	50.667	2.517	1.453
HWSE-P, 20 days	2	44.000	4.243	3.000
HWSE-P, 60 days	2	33.500	2.121	1.500
NQSE, 06 days	3	28.333	2.082	1.202
NQSE, 20 days	2	26.500	.707	.500
NQSE, 60 days	2	31.500	4.950	3.500
PCBs, 06 days	2	14500.000	707.107	500.000
PCBs, 20 days	3	11666.667	577.350	333.333
PCBs, 60 days	1	4500.000	0.000	0.000

from both biomarker and growth studies

ANOVA Output: Treatment Effects (SuperANOVA, Abacus Concepts Inc., Berkeley, CA).
Hepatic HCBD levels from biomarkert study samples (6, 20 d post exposure) and growth study samples (60 d post exposure).

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treatment	5	5595214.226	1119042.845	3.26E2	.0001
Time	2	1704297.803	852148.902	2.48E2	.0001
Treatment * Time	10	9975821.458	997582.146	2.91E2	.0001
Residual	24	82387.045	3432.794		

Dependent: HCBD_conc

Means Table
Effect: Treatment * Time
Dependent: HCBD_conc

	Count	Mean	Std. Dev.	Std. Error
NONE, 0 day	4	.892	.415	.207
Ace/Emulphor, 06 days	2	.430	.057	.040
Ace/Emulphor, 20 days	2	.320	.042	.030
Ace/Emulphor, 60 days	2	.151	.098	.069
HCBD, 06 days	2	2900.000	282.843	200.000
HCBD, 20 days	2	54.500	48.790	34.500
HCBD, 60 days	4	.362	.192	.096
HWSE-M, 06 days	2	2.595	2.270	1.605
HWSE-M, 20 days	2	.260	.014	.010
HWSE-M, 60 days	2	.170	.099	.070
HWSE-P, 06 days	2	1.275	.601	.425
HWSE-P, 20 days	2	.235	.078	.055
HWSE-P, 60 days	2	.185	.106	.075
NQSE, 06 days	2	.310	.014	.010
NQSE, 20 days	2	.540	.438	.310
NQSE, 60 days	2	.335	.049	.035
PCBs, 06 days	1	.350	0.000	0.000
PCBs, 20 days	2	.305	.021	.015
PCBs, 60 days	4	.290	.236	.118

from both biomarker and growth studies

ANOVA Output: Treatment Effects (SuperANOVA. Abacus Concepts Inc.. Berkelev. CA).
Whole body HCBD levels from biomarkert study samples (6, 20 d post exposure) and growth study samples (60 d post exposure).

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treatment	5	327204.976	65440.995	70.014	.0001
Time	2	100833.573	50416.787	53.940	.0001
Treatment * Time	10	497362.097	49736.210	53.212	.0001
Residual	25	23367.172	934.687		

Dependent: HCBD_conc

Means Table
Effect: Treatment * Time
Dependent: HCBD_conc

	Count	Mean	Std. Dev.	Std. Error
NONE, 0 day	4	.037	.009	.004
Ace/Emulphor, 06 days	2	.064	.036	.026
Ace/Emulphor, 20 days	2	.059	.033	.023
Ace/Emulphor, 60 days	2	.311	.380	.269
HCBD, 06 days	2	670.000	141.421	100.000
HCBD, 20 days	2	59.000	57.983	41.000
HCBD, 60 days	3	1.567	.115	.067
HWSE-M, 06 days	2	7.000	.141	.100
HWSE-M, 20 days	2	.086	.047	.034
HWSE-M, 60 days	3	.277	.427	.247
HWSE-P, 06 days	3	1.328	1.515	.875
HWSE-P, 20 days	2	.128	.130	.092
HWSE-P, 60 days	2	.036	.004	.003
NQSE, 06 days	3	.046	.029	.017
NQSE, 20 days	2	.031	.001	.001
NQSE, 60 days	2	.037	.011	.008
PCBs, 06 days	2	.040	.006	.004
PCBs, 20 days	3	.053	.009	.005
PCBs, 60 days	1	.049	0.000	0.000

from both biomarker and growth studies

ANOVA output: Treatment Effects (SuperANOVA, Abacus Concepts Inc., Berkeley, CA).
Hepatic PCB levels (log transformed) at 6 d post exposure.

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treatment	4	5.073	1.268	917.595	.0001
Residual	4	.006	.001		

Dependent: Log PCB

Means Table
Effect: Treatment
Dependent: Log PCB

	Count	Mean	Std. Dev.	Std. Error
Ace/Emulphor	2	1.857	.034	.024
HWSE-M	2	2.230	.036	.026
HWSE-P	2	2.217	.019	.013
NQSE	2	1.850	.052	.037
PCBs	1	4.362	0.000	0.000

Fisher's Protected LSD
Effect: Treatment
Dependant: Log PCB
Significance level: .05

	Vs.	Diff.	Crit. diff.	P-Value	
NQSE	Ace/Emulphor	.007	.103	.8606	
	HWSE-P	.368	.103	.0006	S
	HWSE-M	.380	.103	.0005	S
	PCBs	2.512	.126	.0001	S
Ace/Emulphor	HWSE-P	.361	.103	.0006	S
	HWSE-M	.373	.103	.0006	S
	PCBs	2.505	.126	.0001	S
HWSE-P	HWSE-M	.012	.103	.7553	
	PCBs	2.144	.126	.0001	S
HWSE-M	PCBs	2.132	.126	.0001	S

S = Significantly different at this level.

ANOVA Output: Treatment Effects (SuperANOVA, Abacus Concepts Inc., Berkeley, CA).
Hepatic HCBD levels (log transformed) at 6 d post exposure.

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treatment	5	22.423	4.485	90.510	.0001
Residual	5	.248	.050		

Dependent: Log HCBD

Means Table
Effect: Treatment
Dependent: Log HCBD

	Count	Mean	Std. Dev.	Std. Error
Ace/Emulphor	2	-.368	.057	.041
HCBD	2	3.461	.042	.030
HWSE-M	2	.309	.444	.314
HWSE-P	2	.080	.213	.151
NQSE	2	-.509	.020	.014
PCBs	1	-.456	0.000	0.000

Dunnett Two-Tailed
Effect: Treatment
Dependent: Log HCBD
Significance level: .05

	Vs.	Diff.	Crit. diff.	
Ace/Emulphor	NQSE	-.140	.806	
	PCBs	-.088	.987	
	HWSE-P	.448	.806	
	HWSE-M	.678	.806	
	HCBD	3.830	.806	S

S = Significantly different at this level.

ANOVA Ouput: Treatment Effects (SuperANOVA, Abacus Concepts Inc., Berkeley, CA).
Whole body PCB levels (log transforrmed) at 6 d post exposure.

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treatment	4	11.347	2.837	3656.255	.0001
Residual	7	.005	.001		

Dependent: Log PCB

Means Table
Effect: Treatment
Dependent: Log PCB

	Count	Mean	Std. Dev.	Std. Error
Ace/Emulphor	2	1.446	.044	.031
HWSE-M	2	1.663	0.000	0.000
HWSE-P	3	1.704	.022	.013
NQSE	3	1.451	.032	.019
PCBs	2	4.161	.021	.015

Dunnett Two-Tailed
Effect: Treatment
Dependent: Log PCB
Significance level: .05

	Vs.	Diff.	Crit. diff.	
Ace/Emulphor	NQSE	.005	.079	
	HWSE-M	.217	.087	S
	HWSE-P	.258	.079	S
	PCBs	2.715	.087	S

S = Significantly different at this level.

ANOVA Output: Treatment Effects (SuperANOVA, Abacus Concepts Inc., Berkeley, CA).
Whole body HCBD levels (log transformed) at 6 d post exposure.

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treatment	5	29.772	5.954	23.792	.0001
Residual	8	2.002	.250		

Dependent: Log HCBD

Means Table
Effect: Treatment
Dependent: Log HCBD

	Count	Mean	Std. Dev.	Std. Error
Ace/Emulphor	2	-1.235	.261	.185
HCBD	2	2.821	.092	.065
HWSE-M	2	.845	.009	.006
HWSE-P	3	-.299	.942	.544
NOSE	3	-1.395	.271	.157
PCBs	2	-1.400	.062	.044

Dunnett Two-Tailed
Effect: Treatment
Dependent: Log HCBD
Significance level: .05

	Vs.	Diff.	Crit. diff.	
Ace/Emulphor	PCBs	-.165	1.566	
	NOSE	-.159	1.429	
	HWSE-P	.937	1.429	
	HWSE-M	2.080	1.566	S
	HCBD	4.057	1.566	S

S = Significantly different at this level.

ANOVA Output: Treatment Effects (SuperANOVA, Abacus Concepts Inc., Berkeley, CA).
Hepatic PCB levels (log transformed) at 20 d post exposure.

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treatment	4	8.933	2.233	1353.640	.0001
Residual	5	.008	.002		

Dependent: Log PCB

Means Table
Effect: Treatment
Dependent: Log PCB

	Count	Mean	Std. Dev.	Std. Error
Ace/Emulphor	2	1.761	.064	.045
HWSE-M	2	1.744	.006	.004
HWSE-P	2	1.908	.038	.027
NOSE	2	1.628	.022	.015
PCBs	2	4.113	.047	.033

Dunnett Two-Tailed
Effect: Treatment
Dependent: Log PCB
Significance level: .05

	Vs.	Diff.	Crit. diff.	
Ace/Emulphor	NOSE	-.133	.141	
	HWSE-M	-.017	.141	
	HWSE-P	.147	.141	S
	PCBs	2.352	.141	S

S = Significantly different at this level.

ANOVA Output: Treatment Effects (SuperANOVA, Abacus Concepts Inc., Berkeley, CA).
Hepatic HCBD levels (log transformed) at 20 d post exposure.

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treatment	5	7.755	1.551	23.407	.0007
Residual	6	.398	.066		

Dependent: Log HCBD

Means Table
Effect: Treatment
Dependent: Log HCBD

	Count	Mean	Std. Dev.	Std. Error
Ace/Emulphor	2	-.497	.058	.041
HCBD	2	1.625	.458	.324
HWSE-M	2	-.585	.024	.017
HWSE-P	2	-.641	.146	.104
NQSE	2	-.354	.401	.284
PCBs	2	-.516	.030	.021

Dunnett Two-Tailed
Effect: Treatment
Dependent: Log HCBD
Significance level: .05

	Vs.	Diff.	Crit. diff.	
Ace/Emulphor	HWSE-P	-.144	.873	
	HWSE-M	-.089	.873	
	PCBs	-.019	.873	
	NQSE	.142	.873	
	HCBD	2.122	.873	S

S = Significantly different at this level.

ANOVA Output: Treatment Effects (SuperANOVA, Abacus Concepts Inc., Berkeley, CA).
Whole body PCB levels (log transformed) at 20 d post exposure.

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treatment	4	14.228	3.557	5630.935	.0001
Residual	6	.004	.001		

Dependent: Log PCB

Means Table
Effect: Treatment
Dependent: Log PCB

	Count	Mean	Std. Dev.	Std. Error
Ace/Emulphor	2	1.415	0.000	0.000
HWSE-M	2	1.602	.031	.022
HWSE-P	2	1.642	.042	.030
NQSE	2	1.423	.012	.008
PCBs	3	4.067	.022	.013

Dunnett Two-Tailed
Effect: Treatment
Dependent: Log PCB
Significance level: .05

	Vs.	Diff.	Crit. diff.	
Ace/Emulphor	NQSE	.008	.082	
	HWSE-M	.187	.082	S
	HWSE-P	.227	.082	S
	PCBs	2.652	.075	S

S = Significantly different at this level.

ANOVA Output: Treatment Effects (SuperANOVA, Abacus Concepts Inc., Berkeley, CA).
Whole body HCBD levels (log transformed) at 20 d post exposure.

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treatment	5	14.212	2.842	27.402	.0002
Residual	7	.726	.104		

Dependent: Log HCBD

Means Table
Effect: Treatment
Dependent: Log HCBD

	Count	Mean	Std. Dev.	Std. Error
Ace/Emulphor	2	-1.265	.253	.179
HCBD	2	1.628	.527	.372
HWSE-M	2	-1.098	.251	.177
HWSE-P	2	-1.051	.556	.393
NOSE	2	-1.509	.020	.014
PCBs	3	-1.278	.079	.046

Dunnett Two-Tailed
Effect: Treatment
Dependent: Log HCBD
Significance level: .05

	Vs.	Diff.	Crit. diff.	
Ace/Emulphor	NOSE	-.244	1.044	
	PCBs	-.013	.953	
	HWSE-M	.167	1.044	
	HWSE-P	.214	1.044	
	HCBD	2.893	1.044	S

S = Significantly different at this level.

ANOVA Output: Treatment Effects (SuperANOVA. Abacus Concepts Inc., Berkerley. CA).
Hepatic PCB levels (log transformed) at 60 d post exposure.

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treatment	5	9.692	1.938	733.521	.0001
Residual	8	.021	.003		

Dependent: Log PCB

Means Table
Effect: Treatment
Dependent: Log PCB

	Count	Mean	Std. Dev.	Std. Error
Ace/Emulphor	2	1.201	.077	.055
HCBD	2	1.227	.073	.051
HWSE-M	2	1.230	.036	.026
HWSE-P	2	1.276	.065	.046
NCSE	2	1.161	.021	.015
PCBs	4	3.060	.036	.018

Dunnett Two-Tailed
Effect: Treatment
Dependent: Log PCB
Significance level: .05

	Vs.	Diff.	Crit. diff.	
Ace/Emulphor	NCSE	-.040	.161	
	HCBD	.027	.161	
	HWSE-M	.029	.161	
	HWSE-P	.076	.161	
	PCBs	1.859	.139	S

S = Significantly different at this level.

ANOVA Output: Treatment Effects (SuperANOVA, Abacus Concepts Inc., Berkeley, CA).
Whole Body PCB levels (log transformed) at 60 d post exposure.

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treatment	5	4.085	.817	28.490	.0002
Residual	7	.201	.029		

Dependent: Log PCB

Means Table
Effect: Treatment
Dependent: Log PCB

	Count	Mean	Std. Dev.	Std. Error
Ace/Emulphor	2	1.525	.110	.077
HCBD	3	1.625	.300	.173
HWSE-M	3	1.571	.041	.024
HWSE-P	2	1.525	.028	.019
NOSE	2	1.496	.069	.048
PCBs	1	3.653	0.000	0.000

Dunnett Two-Tailed
Effect: Treatment
Dependent: Log PCB
Significance level: .05

	Vs.	Diff.	Crit. diff.	
Ace/Emulphor	NOSE	-.029	.549	
	HWSE-P	2.168E-19	.549	
	HWSE-M	.046	.501	
	HCBD	.100	.501	
	PCBs	2.129	.672	S

S = Significantly different at this level.

ANOVA Output: Treatment Effects (SuperANOVA, Abacus Concepts Inc., Berkeley, CA).
Hepatic HCBD levels (log transformed) at 60 d post exposure.

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treatment	5	.325	.065	.755	.6016
Residual	10	.861	.086		

Dependent: Log HCBD

Means Table
Effect: Treatment
Dependent: Log HCBD

	Count	Mean	Std. Dev.	Std. Error
Ace/Emulphor	2	-.872	.303	.214
HCBD	4	-.503	.294	.147
HWSE-M	2	-.810	.269	.190
HWSE-P	2	-.772	.264	.187
NCSE	2	-.477	.064	.046
PCBs	4	-.644	.348	.174

Dunnett Two-Tailed
Effect: Treatment
Dependent: Log HCBD
Significance level: .05

	Vs.	Diff.	Crit. diff.
Ace/Emulphor	HWSE-M	.062	.877
	HWSE-P	.100	.877
	PCBs	.228	.760
	HCBD	.368	.760
	NCSE	.395	.877

None were significantly different at this level.

ANOVA Output: Treatment Effects (SuperANOVA, Abacus Concepts Inc., Berkeley, CA).
Whole body HCBD levels (log transformed) at 60 d post exposure.

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Treatment	5	5.016	1.003	3.495	.0667
Residual	7	2.010	.287		

Dependent: Log HCBD

Means Table
Effect: Treatment
Dependent: Log HCBD

	Count	Mean	Std. Dev.	Std. Error
Ace/Emulphor	2	-.807	.806	.570
HCBD	3	.194	.031	.018
HWSE-M	3	-1.053	.818	.472
HWSE-P	2	-1.445	.051	.036
NOSE	2	-1.442	.135	.095
PCBs	1	-1.310	0.000	0.000

Dunnett Two-Tailed
Effect: Treatment
Dependent: Log HCBD
Significance level: .05

	Vs.	Diff.	Crit. diff.
Ace/Emulphor	HWSE-P	-.639	1.736
	NOSE	-.636	1.736
	PCBs	-.503	2.126
	HWSE-M	-.246	1.585
	HCBD	1.001	1.585

None were significantly different at this level.