

# Puget Sound Toxic Loading Analysis: Hazard Evaluation for Chemicals of Concern in the Puget Sound Basin – Methodology and Results

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## Introduction

In 2006, the WA State Department of Ecology (Ecology) and other agencies initiated the multi-phase Puget Sound Toxics Loading Analysis (PSTLA) to evaluate sources and major delivery pathways (surface runoff, groundwater, publicly owned treatment works, and direct air deposition) for a select group of chemicals of concern (COCs) (Table 1) in Puget Sound. The effort provided key information on loading/delivery pathways and primary chemical sources; however, it did not provide insight on the potential for COCs to cause impacts. To fill this data gap, a broad scale screening-level hazard evaluation assessment was conducted to better understand the potential for the COCs to cause adverse effects to aquatic life, wildlife and to a lesser extent, people. A consistent methodology was developed to prioritize COCs in various media and pathways. The hazard evaluation provides broad scale information about the relative potential for effects posed by the COCs at observed concentrations in the Puget Sound basin. The hazard assessment will be combined with PSTLA findings to establish a scientifically based source control strategy for toxic chemicals in the Puget Sound Basin and to prioritize actions. A brief summary of the methods and outcome of the hazard assessment is presented here.

**Table 1.** Chemicals of concern evaluated by the hazard assessment

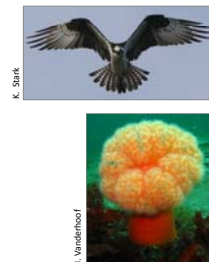
Chemicals of Concern		
Arsenic	Zinc	Dioxins/Furans
Cadmium	PCBs	Bis(2-Ethylhexyl) Phthalate
Copper	PBDEs	Triclopyr
Lead	DDTs	Nonylphenol
Mercury	PAHs	Petroleum



## Methods

To assess relative hazards, observed COC concentrations in sediment, water and tissue were compared to available effects data, guidelines, standards, and/or criteria to evaluate:

- Direct hazard to aquatic life via surface water exposure
- Direct hazard to benthic organisms via sediment exposure
- Direct hazard to aquatic life based on tissue residue levels
- Hazard to wildlife based on ingestion (prey, water, sediment)
- Hazard to human health through fish/seafood consumption



## Environmental Data Collection

Environmental data collected between 1/1/00 - 7/1/10 were obtained from readily available databases/sources to estimate COC exposure concentrations; data were differentiated into three course spatial scales; (1) freshwater, (2) marine nearshore and (3) marine offshore.

## Identification of Effects Data

Effects data were obtained from readily available databases. Regional data were also evaluated; however, since most did not generate dose-response relationships, or were based on lipid normalized data, multiple exposures or field studies, they were not appropriate for direct comparison with observed COC data. Regional data were used as an additional line of evidence (LOE) and described in greater detail in the Assessment Report (Ecology 2011).

## Surface Water Effects

EPA's ECOTOXicology (ECOTOX) database (<http://cfpub.epa.gov/ecotox>) was the primary source of effects data. When available, water quality criteria were also used.

## Sediment Effects

The WA State Marine Sediment Management Standards and Ecology's Floating Percentile based freshwater sediment guidelines were the primary thresholds used. When available, other sediment guidelines were used to provide additional context.

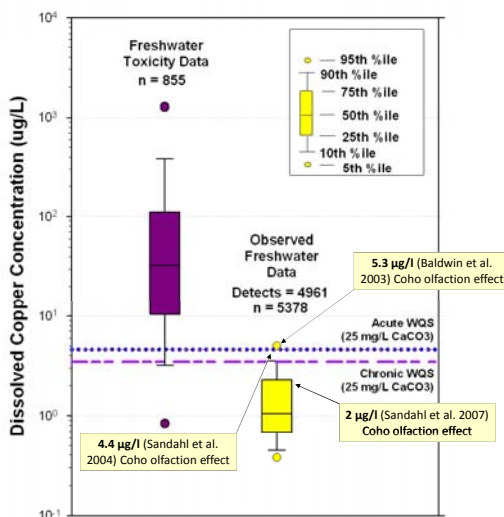
## Human Health

The National Toxics Rule (NTR) 40CFR§131.36 criteria were used as the primary human health thresholds. The NTR consumption rate (6.5 gm/d) is considered under-protective for some populations and ethnic groups; other national/regional fish consumption rates were used to provide perspective: EPA recreation/subsistence (17.5 and 142.4 gm/d) Tulalip/API (242.5 gm/d) Suquamish Tribal (769 gm/d) COCs not included in the NTR were not assessed.

Washington Department of Ecology Publication No. 11-03-068

## Hazard Assessment

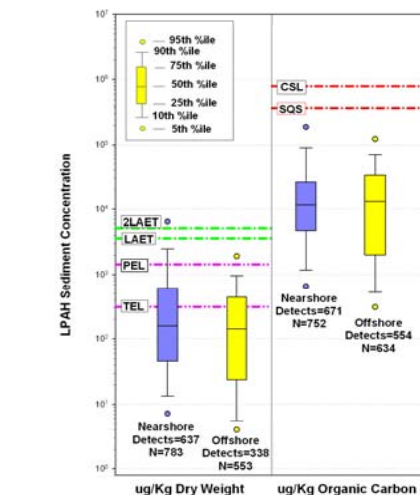
- Observed environmental data were compared to the respective effects data to classify the COCs into one of three categories; Priority 1, Priority 2 or Unknown ("U").
- A classification of Priority 2 or "U" is not intended to suggest that this COC is not a concern; it is assumed that all COCs are priorities at some level.



**Figure 1.** Example of surface water hazard evaluation; copper is a Priority 1 COC.

## Water – Direct Exposure Effects

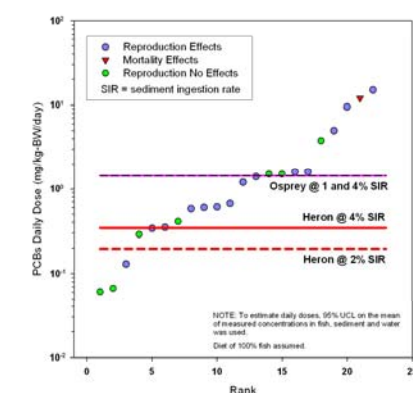
- Priority 1** - 90<sup>th</sup> %ile COC concentration > 10<sup>th</sup> %ile of the effect concentrations (**Figure 1**).
- Priority 2** - 90<sup>th</sup> %ile COC concentration < 10<sup>th</sup> %ile of the effect concentrations.
- "U"** - insufficient data (<15 effects or <50 observed values).



**Figure 2.** Example of sediment hazard evaluation; LPAHs are a Priority 2 COC.

## Sediment – Direct Effects to Benthic Organisms

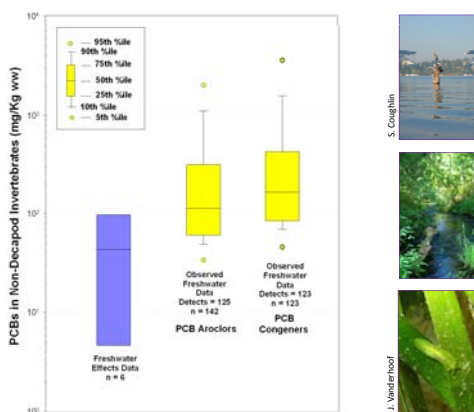
- Priority 1** - 90<sup>th</sup> %ile COC concentration > marine SQS or freshwater FP-SQS.
- Priority 2** - 90<sup>th</sup> %ile COC concentration < marine SQS or freshwater FP-SQS (**Figure 2**).
- "U"** - insufficient data (<100 observed values) or lack of threshold.



**Figure 3.** Example of wildlife evaluation; PCBs are a Priority 1 COC for Osprey and Heron.

## Wildlife - Effects via Ingestion

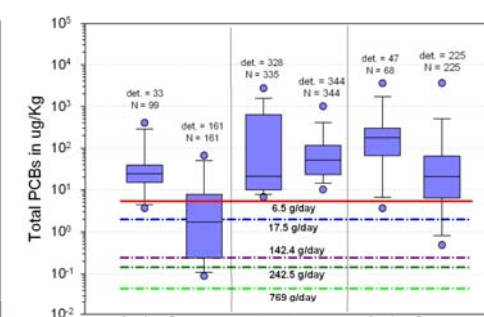
- Priority 1** - estimated daily dose within a factor of 10 of the lowest effect dose (**Figure 3**).
- Priority 2** - estimated daily dose < an order of magnitude (i.e., factor of 10) of the lowest effect dose.
- "U"** - insufficient data (<5 effects values).



**Figure 4.** Example of tissue residue evaluation; PCBs are a Priority 1 COC for freshwater non-decapod invertebrates tissue.

## Tissue Residue – Direct Effects

- Priority 1** - 90<sup>th</sup> %ile TR COC concentration > 10<sup>th</sup> %ile of the effect concentrations (**Figure 4**).
- Priority 2** - 90<sup>th</sup> %ile TR COC concentration < 10<sup>th</sup> %ile of the effect concentrations.
- "U"** - insufficient data (<5 effects or <20 observed values).
- Both TR effects and observed data were limited; the reader is encouraged to take this into account when interpreting the TR results.



**Figure 5.** Example of human health evaluation; PCBs are a Priority 1 COC for human health.

## Human Health – Ingestion of Seafood

- Priority 1** - 90<sup>th</sup> %ile COC tissue concentration > NTR criteria (**Figure 5**).
- Priority 2** - 90<sup>th</sup> %ile COC tissue concentration < NTR criteria.
- "U"** - insufficient data.



## Uncertainty

This hazard evaluation provides a broad overview of the potential for the COCs evaluated to cause adverse ecological and human health effects; however, a number of uncertainties should be taken into consideration when interpreting the results. The reader is encouraged to review the Assessment Report (Ecology 2011) to fully understand the uncertainty and limitations. Below are a few examples of uncertainty.

- NTR criteria were only available for half of the COCs; this poses a significant uncertainty regarding the potential for COCs not evaluated to cause human health effects.
- The petroleum effects data were limited to dissolved concentrations of fuel and lubricating oils, and water-product mixtures in surface waters. Data limitations result in a high level of uncertainty for the petroleum assessment.
- There is significant uncertainty associated with the number and type of available TR effect concentrations; in some cases only one or two TR effect levels were available for a COC and/or tissue type. Some TR data were limited to mortality endpoints, likely underestimating the prioritization of these COCs and tissue types.
- Some of the greatest uncertainty in the surface water assessment was associated with lack of effects data for some COCs, particularly for marine organisms and dissolved metals.
- For all but the human health assessment, there is uncertainty associated with the effects data related to species sensitivity, exposure condition, test duration, appropriateness of endpoints evaluated, and endpoint type. An additional uncertainty was the lack of non-mortality based effects data for some COCs and media.

## Results

A primary goal of the hazard assessment was to use a consistent methodology to prioritize COCs of greatest concern for further action. The following provides a summary of the prioritization outcome:

- Cu, Hg, Zn, PCBs, Dioxin/Furans, DDTs and a number of individual PAHs were classified as Priority 1 by more than one LOE (**"Multiple Priority 1"** - **Table 2**) and represent COCs with the greatest potential for widespread environmental impacts that warrant action.
  - As, Cd, PBDEs, LPAH, HPAH and a number of individual PAHs were classified as Priority 1 by one LOE (**"Single Priority 1"** - **Table 2**) and represent COCs with high potential for widespread environmental impacts that warrant action.
  - Pb, Benzo(a)anthracene, triclopyr, nonylphenol and petroleum were not classified as Priority 1 by any LOE (**"No Priority 1"** - **Table 2**) and represent COCs with ongoing concern about their impacts, but for which limited evidence is available to allow prioritization.
- Some COCs were not evaluated for some LOE due to limited availability of observed or effects data. These COCs may warrant action based on existing concerns not captured by the current assessment.

**Table 2.** Overall COC grouping based on all lines of evidence.

Multiple Priority 1 Classifications		Single Priority 1 Classifications		No Priority 1 Classifications
Copper	Bis(2-ethylhexyl)phthalate	Arsenic	Acenaphthylene	Lead
Mercury	Benzo(a)pyrene	Cadmium	Chrysene	Benzo(a)anthracene
Zinc	Dibenzo(a,h)anthracene	PBDEs	Fluoranthene	Triclopyr
PCBs	Indeno(1,2,3-cd)pyrene	LPAHs	Fluorene	Nonylphenol
Dioxins/Furans	Benzo(b)fluoranthene	HPAHs	Naphthalene	Petroleum
DDT/DDE/DDD	Benzo(k)fluoranthene	Anthracene	Phenanthrene	
		Benzo(ghi)perylene	Pyrene	
		Acenaphthene		