Use of Relative Risk Assessment for Developing Regulatory Guidance: Case Study for Managing Dredged Material at Puget Sound Open-Water Disposal Sites

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Abstract

Risk assessment is a commonly used tool for determining the need for remediation. In that familiar context, point risk estimates are typically compared with thresholds that trigger remedial action. However, this model rarely includes a comparison of site-related risks relative to risks at other locations. Such an approach is valuable in that it provides a context for risk managers at contaminated sites. The relative risk approach can also be used in developing regulations for discharging chemicals into the environment, as shown in this case study. In 2006, the Dredged Material Management Program (DMMP) agencies determined that a revised policy for managing dioxins/furans in dredged material was necessary because risks associated with dioxins/furans in seafood that people could consume from the vicinity of the Anderson-Ketron dredged material disposal site were unacceptably high. Similarly, seafood consumption risks from background areas of Puget Sound were unacceptably high. Consequently, the DMMP agencies concluded that dioxin/furan concentrations in dredged material placed at open-water disposal sites in Puget Sound should be no higher than dioxin/furan concentrations in sediment from other areas of Puget Sound. This conclusion was based on the premise that concentrations of dioxins/furans in seafood species that were collected from the disposal sites and potentially consumed by people were correlated with dioxin/furan concentrations in dredged material placed at the disposal sites. However, this conclusion was never tested, and tissue concentrations at the disposal sites were never compared with tissue concentrations at background areas. Without such analyses, it is not clear that a revised disposal policy is actually needed. These analyses were conducted as part of this case study. One advantage of such an approach is the ability to focus on the relative exposure among different areas, rather than on discrete risk estimates, thus avoiding entanglement in the policy-laden question of whether risks are acceptable. The results of this case study indicate that the dredged material disposal regulations that have been in place for the past 20 years have not resulted in appreciable differences in potential exposure to dioxins/furans for people who might eat seafood from the vicinity of dredged material disposal areas, as compared with those who might eat seafood from other areas of Puget Sound. This conclusion is based on a relatively small amount of available data from the disposal sites; additional data collection and analyses may be warranted to refine the analyses presented in this case study.

Introduction

- DMMP agencies regulate the quality of dredged material disposed of at Puget Sound open-water disposal sites largely through the use of sediment chemistry data.
- Historically, testing for dioxins/furans in dredged material was rarely required.
- Recent testing by DMMP agencies at open-water disposal sites indicated that dioxin/furan concentrations in sediment from those sites were higher than those in sediment from background areas.
- To protect Puget Sound seafood consumers, DMMP agencies concluded that dioxin/furan concentrations in sediment at disposal sites should not be higher than those in sediment at background areas.

Questions and Answers

Question 1:

Are dioxin/furan concentrations in sediment at disposal sites correlated with dioxin/furan concentrations in seafood species collected at disposal sites?

Answer:

- From 2005 to 2008, the DMMP agencies collected sediment and tissue samples from five open-water disposal sites and analyzed the samples for dioxins/furans (SAIC 2008).
- Sediment toxic equivalents (TEQs) ranged from 0.7 to 22 ng/kg, with disposal site averages ranging from 3.1 (Commencement Bay) to 8.2 ng/kg (Bellingham Bay).
- Tissue TEQs ranged from 0.070 to 0.918 ng/kg, with disposal site averages ranging from 0.12 (Bellingham Bay) to 0.66 ng/kg (Commencement Bay).
- No significant relationship exists between sediment and tissue TEQs (Figure 1), as determined by a regression of location means (p = 0.27 ng/kg).

Figure 1. Comparison of dioxin/furan TEQs in sediment and tissue samples collected at open-water disposal sites

Question 2:

Do dioxin/furan concentrations in the tissue of seafood species collected at disposal sites differ from dioxin/furan concentrations in the tissue of species collected elsewhere in Puget Sound?

Answer:

- Since 1999, 329 Puget Sound seafood samples have been analyzed for dioxins/furans, including samples from five dredged material disposal sites (Table 1 and Figure 2).
- With the exception of two outliers, all dioxin/furan TEQ concentrations were less than 2 ng/kg; average concentrations for each combination of location type (disposal, contaminated, other) and tissue type (decapod, bivalve, fish) were less than 1 ng/kg.
- There are no significant differences between dioxin/furan TEQ concentrations at the three location types (one-way analysis of variance, p = 0.55) (Figure 3).

Table 1. Summary of Puget Sound dioxin/furan fish and shellfish chemistry studies from 1999 to 2008

Study	Nearest City	Location Type[a]	Year	Number of Samples by Species Type			
				Bivalve[b]	Decapod[c]	Fish[d]	Total
Anderson-Ketron disposal site monitoring	Steilacoom	disposal	2006, 2007	0	3	3	**6**
Bellingham Bay disposal site monitoring	Bellingham	disposal	2007	0	3	4	**7**
Bioaccumulative toxics in Native American shellfish	Anacortes	other	2002, 2003	31	9	0	**40**
Budd Inlet sediment characterization	Olympia	contaminated, other	2007	6	0	16	**22**
Commencement Bay disposal site monitoring	Tacoma	disposal	2007	0	0	3	**3**
Elliott Bay disposal site monitoring	Seattle	disposal	2007	0	1	3	**4**
Fidalgo Bay sediment investigation	Anacortes	other	2007	6	14	6	**26**
Former Rayonier Mill RI/FS, Phase 1	Port Angeles	contaminated, other	2002	36	26	2	**64**
Former Rayonier Mill RI/FS, Phase 2	Port Angeles	contaminated, other	2006	40	23	0	**63**
Health consultation for dioxins/furans in Oakland Bay shellfish	Shelton	other	2009	22	0	0	**22**
Padilla Bay shellfish screening for metals and organics	Anacortes	other	1999	6	4	0	**10**
Pope and Talbot mill site tissue	Port Gamble	contaminated, other	2003	5	0	0	**5**
Port Angeles Harbor sediment investigation	Port Angeles	contaminated, other	2008	12	0	4	**16**
Port Gamble Bay RI/FS	Port Gamble	contaminated	2008	7	1	0	**8**
Port Gardner disposal site monitoring	Everett	disposal	2006	0	3	3	**6**
Sediment characterization study in Port Gardner and Lower Snohomish Estuary	Everett	other	2008	2	3	3	**8**
South Puget Sound fish and shellfish tissue verification of 303(d) listings	Olympia	contaminated	2005	3	0	0	**3**
Surface sediment and fish tissue chemistry in Greater Elliott Bay	Seattle	contaminated, other	2007	0	0	16	**16**
Total				**176**	**90**	**63**	

[a] Location types include disposal (DMMP open-water disposal site for dredged material), contaminated (part of the study area for a contaminated site investigation), and other (background locations or bay-wide reconnaissance-level investigation locations).

[b] Bivalve species included *Crassostrea gigas* (Pacific oyster), *Crassostrea sikamea* (Olympic oyster), *Mya arenaria* (Eastern softshell clam), *Mytilus trossulus* (bay mussel), *Panopea abrupta* (geoduck), *Protothaca staminea* (littleneck clam), *Saxidomus gigantea* (butter clam), *Tapes philippinarum* (Manila clam), and *Tresus capax* (horse clam).

[c] Decapod species included *Cancer magister* (Dungeness crab), *Cancer productus* (red rock crab), and *Pandalus danae* (coon-stripe shrimp). Crab samples included only edible meat (hepatopancreas data were also available but were not evaluated).

[d] Fish species included *Lepidopsetta bilineata* (rock sole), *Parophrys vetulus* (English sole), *Platichthys stellatus* (starry flounder), and *Sebaste* spp. (rockfish). Fish samples were fillets.

DMMP – Dredged Material Management Program FS – feasibility study RI – remedial investigation

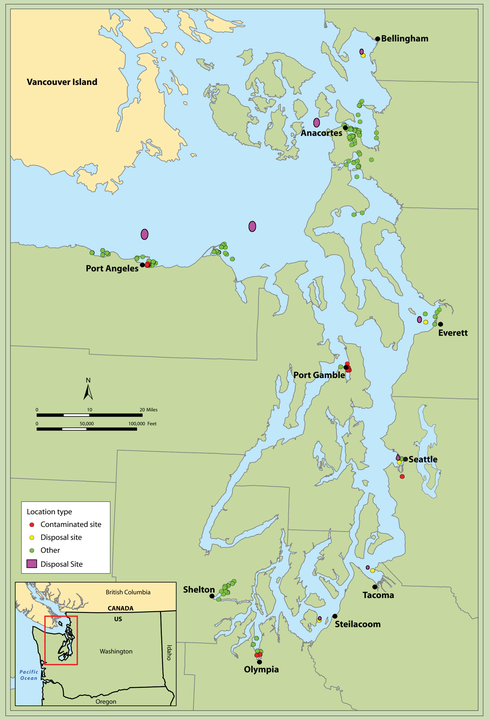

Figure 2. Puget Sound dioxin/furan tissue sampling locations

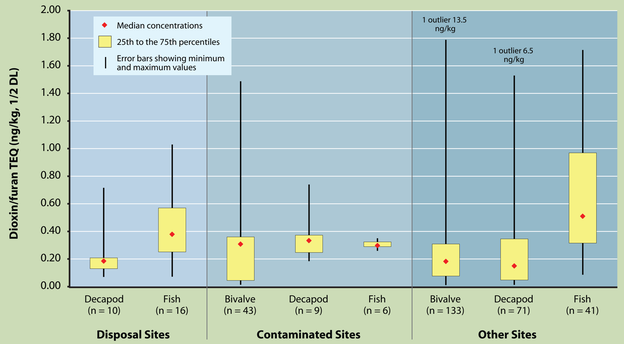

Figure 3. Comparison of dioxin/furan TEQs by location and sample type

Question 3:

What are the dioxin/furan risks associated with consuming seafood from disposal areas and other Puget Sound areas?

Answer:

- Dioxins/furans are highly toxic, so risk estimates are often higher than regulatory thresholds of concern, even for relatively low concentrations.
- Excess cancer risk estimates for dioxins/furans in Puget Sound seafood range from 3×10^{-7} for two meals per year (1.24 g/day on an annualized basis) to 3×10^{-5} for three meals per week (97 g/day on an annualized basis) (Figure 4).

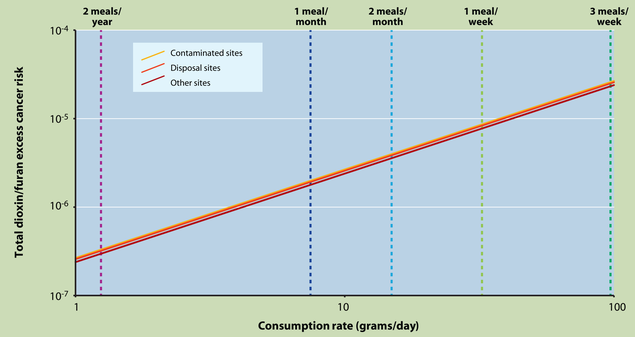

Figure 4. Hypothetical dioxin/furan excess cancer risk estimates associated with the consumption of Puget Sound seafood

Conclusions

- Dioxin/furan concentrations (and therefore associated excess cancer risks) in seafood captured near dredged material disposal sites are not significantly different from dioxin/furan concentrations in seafood captured in other areas of Puget Sound.
- Recently updated DMMP guidance intended to protect seafood consumers from excess cancer risks from dioxins/furans in seafood captured near dredged material disposal sites provides no appreciable benefit to Puget Sound seafood consumers.
- DMMP guidance established 20 years ago for managing the quality of dredged material placed at open-water disposal sites is sufficiently protective of seafood consumers with respect to dioxins/furans.

References

SAIC. 2008. Dioxin/furan concentrations at the non-dispersive open-water dredged material disposal sites in Puget Sound. Prepared for Washington State Department of Natural Resources. Science applications International Corporation, Bothell, WA.