Northwest Power and Conservation Council

July 2, 2008

MEMORANDUM

TO: Council Members

FROM: Jim Ruff, Manager, Mainstem Passage and River Operations

SUBJECT: NOAA's Northwest Fisheries Science Center presentation on recent research on the effects of toxic contaminants on salmon

At the July 15, 2008, Council meeting in Kalispell, Montana, Tracy Collier and Lyndal Johnson from NOAA's Northwest Fisheries Science Center in Seattle will provide a briefing on recent research on the effects of toxics on salmonids. Dr. Collier is the Director of the Environmental Conservation Division at the NOAA Science Center and Lyndal Johnson is leader of the Reproductive Toxicology Team in the Ecotoxicology and Environmental Fish Health Program.

They will address the Council's June 17th letter with its list of questions concerning the effects of toxic contaminants on salmon (Attachment). To that end, they will present the results to date of the Northwest Fisheries Science Center's collaborative surveys of toxic chemical exposures and effects in outmigrating juvenile salmon collected at several sites in the lower Columbia River. They will put these levels of exposure in context with other investigations in what were presumed to be more highly contaminated estuaries. Finally, they will present results comparing the projected increased mortality resulting from contaminant exposure in the lower Columbia River to that projected from stress associated with passage through portions of the hydropower system.

Attachment

w:\jr\ww\2008\5-22-08 nwfsc toxics present.doc

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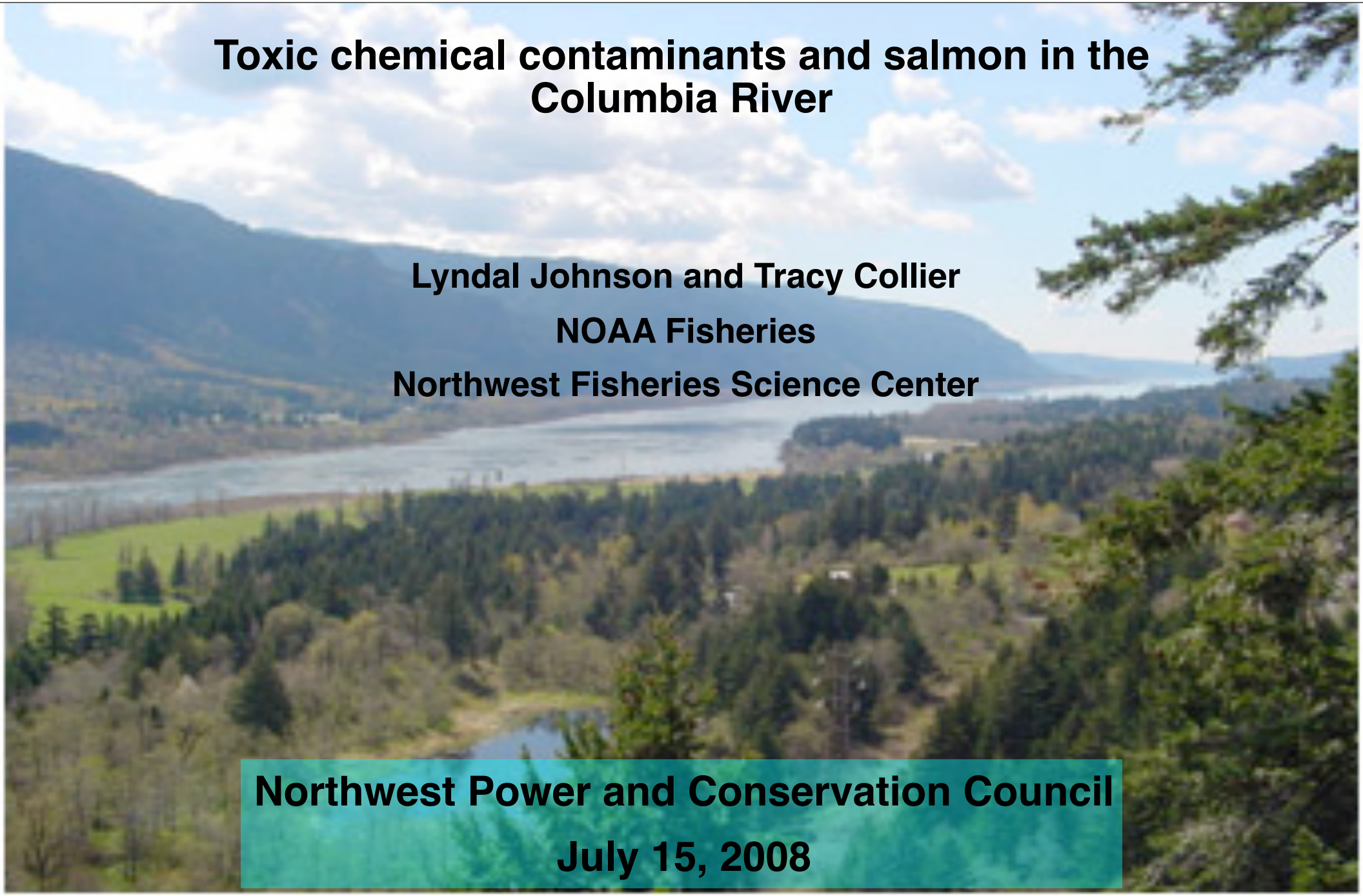
Toxic chemical contaminants and salmon in the Columbia River

Lyndal Johnson and Tracy Collier

NOAA Fisheries

Northwest Fisheries Science Center



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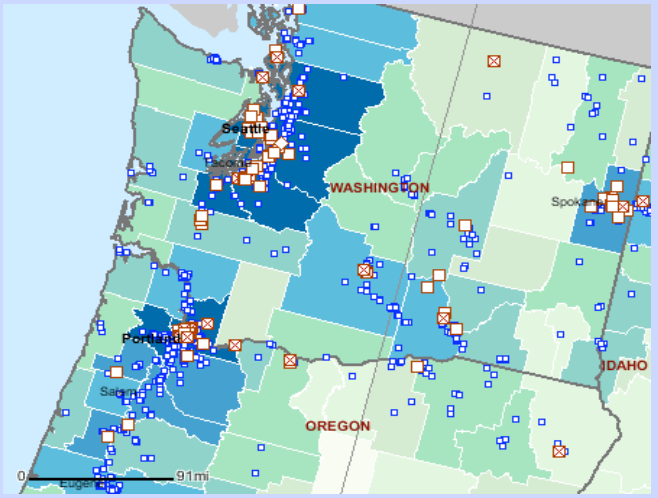
Dam construction and operation as a source of toxics in the Columbia?

- Localized spills or disposal of contaminants (e.g., PCBs at Bradford Island).
- Contaminant accumulation in sediments behind dams.
- Direct* contributions likely < 5% of loadings.

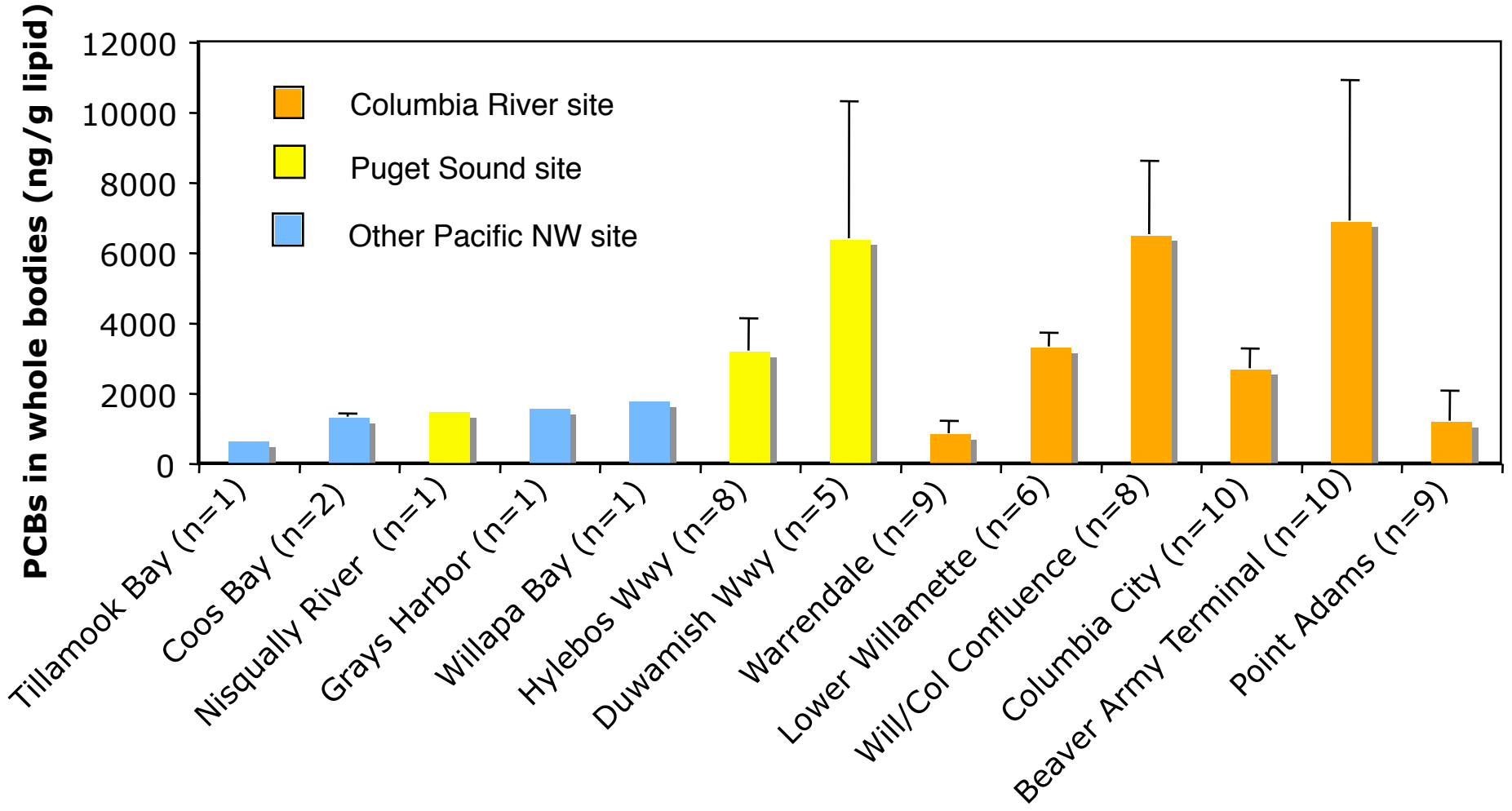
*By facilitating agriculture and providing power for urban development, may indirectly contribute to releases of pesticides and urban/ industrial contaminants

Persistent organic pollutants are found in juvenile salmon throughout the Pacific Northwest

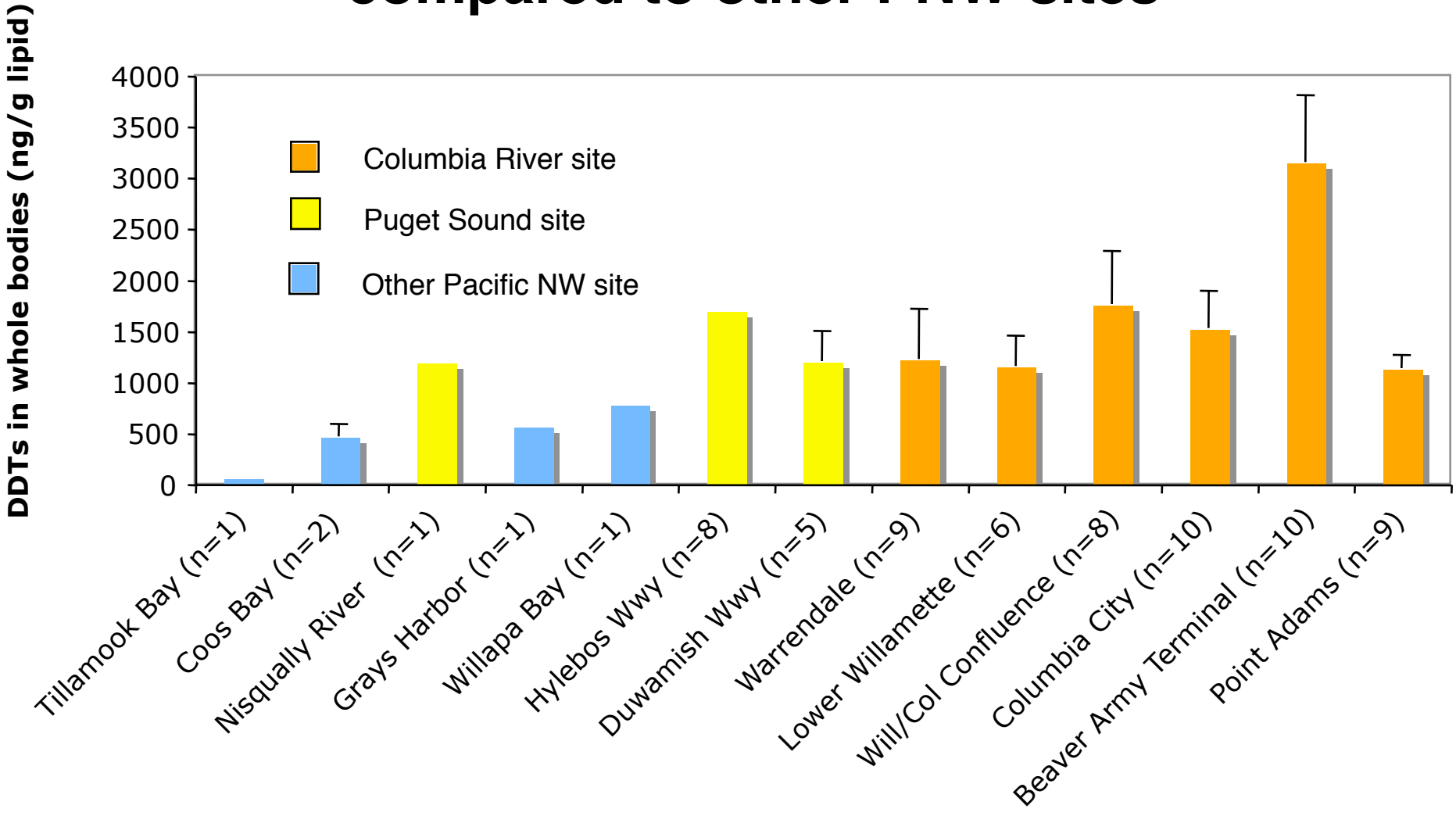


Superfund Sites
and
Toxic Release Sources

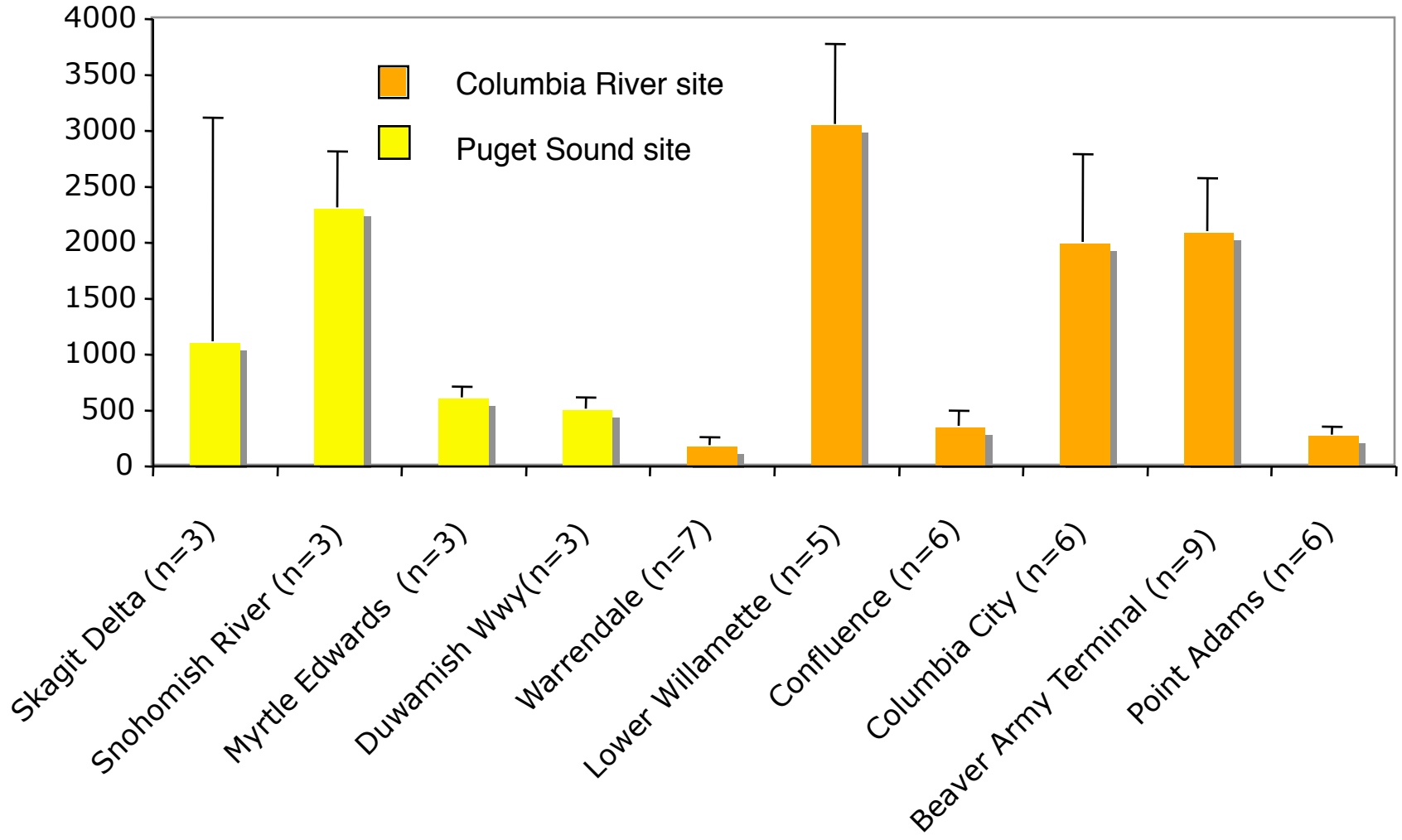
PCBs in Columbia River juvenile salmon compared to other PNW sites



DDTs in Columbia River juvenile salmon compared to other PNW sites



PBDEs in Columbia River juvenile salmon compared to other PNW sites

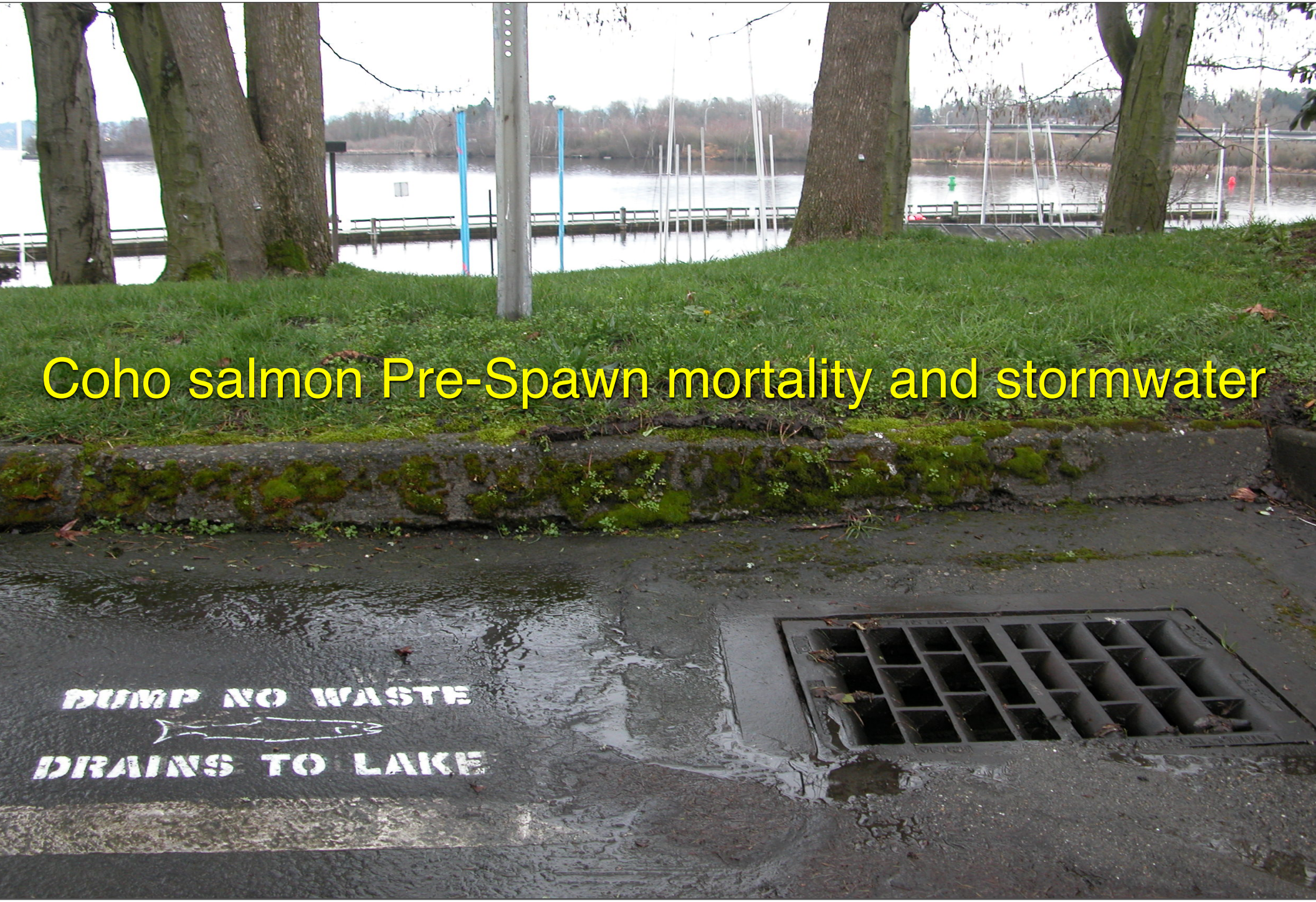


Lethal effects of toxic contaminants on salmon

--Pre-spawn mortality in coho salmon, linked to stormwater;

--Synergistic effects of pesticides leading to unpredicted mortality;

--Developmental defects causing egg and larval mortality, linked to stormwater and PAHs.


Coho salmon Pre-Spawn mortality and stormwater
DUMP NO WASTE
DRAINS TO LAKE

Symptomatic fish observed in Longfellow Creek, Fall 2002.


Study Sites
Fortson 0.9%
Vancouver
Seattle
Washington
Portland
Piper's 54.7%
Thornton 85.7%
71.2% Longfellow
23.8% Fauntleroy
Seattle
Bellevue
Des Moines 63.3%
Bainbridge Island
Treasure Island
Duwamish Island
Foster Island
Harbor Island
Ohlers Island
Mercer Island
Kellogg Island
S 128TH St
S 176TH St
S 180TH St
S 188TH St
S 200TH St
S 212TH St
SE 192ND St
SE 208TH St
SE Renton-Maple Valley Rd
NE 4TH St
Image © 2006 TerraMetrics
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Streaming 100%

Pesticides commonly occur as mixtures in fish habitats

Greater than 80% of urban streams contain three or more pesticides.
(Hoffman et al., 2000, *Environ. Toxicol. Chem*. 19, 2249-2258)

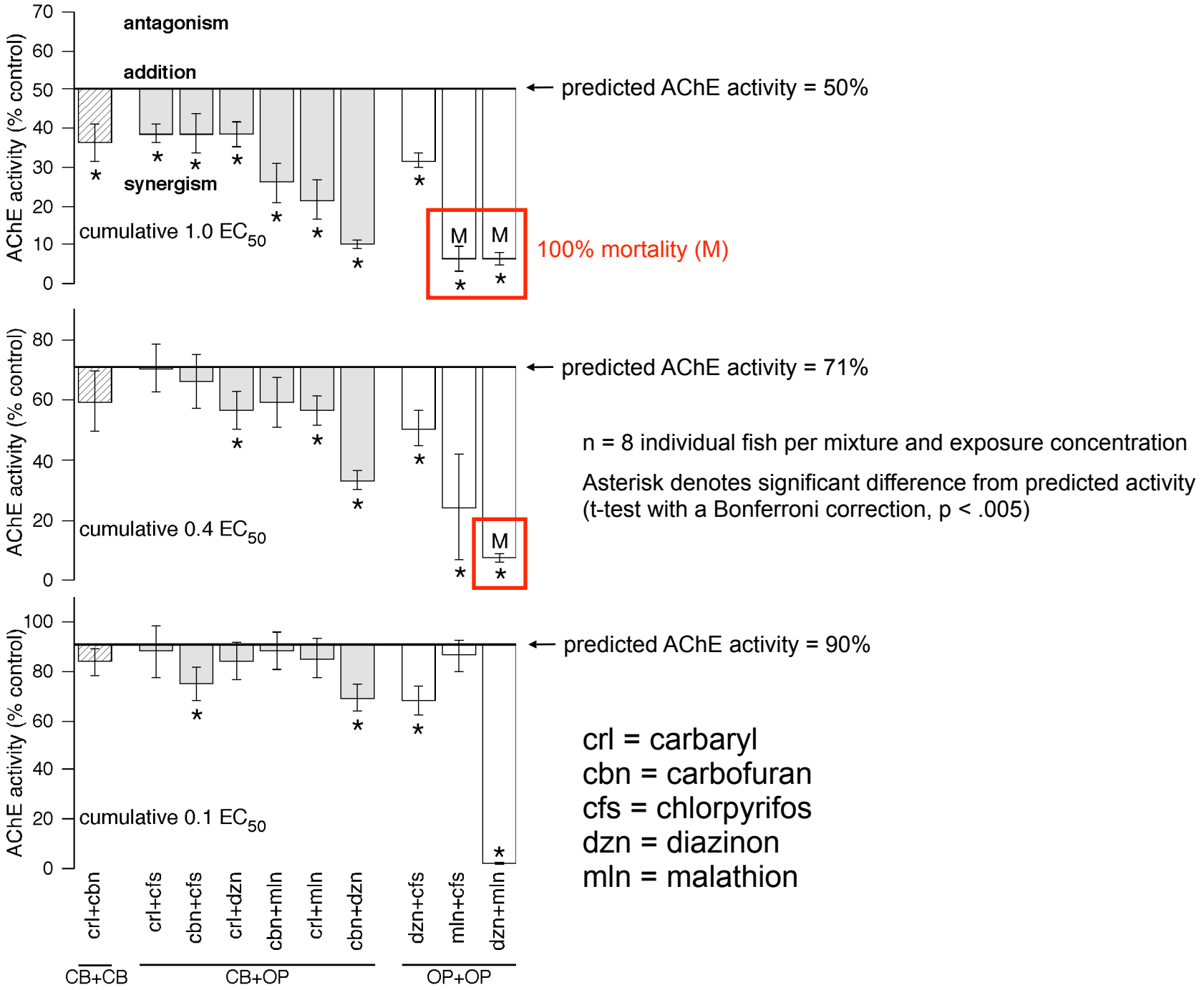
More than 90% of urban, agricultural, and mixed-use streams contain 2 or more pesticides.
(Gilliom et al., 2006, *USGS Circular 1291*)

Frequency of Insecticide Detections in Surface Water

NAWQA Study Area	Diazinon	Malathion	Chlorpyrifos	Carbaryl	Carbofuran
Puget Sound	48%	D	3%	D	D
Central Columbia	4%	2%	9%	6%	5%
Yakima River	18%	D	D	90%	ND
Willamette	35%	5%	21%	18%	29%
Sacramento River	75%	33%	38%	60%	36%
San Joaquin-Tulare	71%	8%	52%	25%	5%

D= detected, frequency not reported
ND=not detected

Data from U.S. Geological Survey NAWQA Circulars 1237, 1159, 1161, 1216, 1144 and 1215

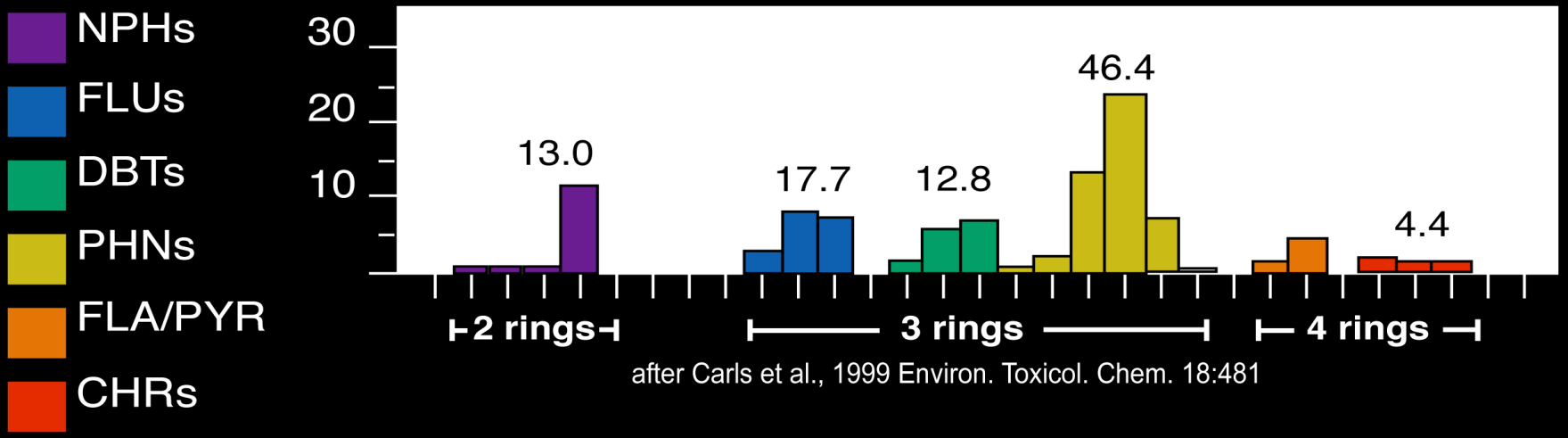


n = 8 individual fish per mixture and exposure concentration

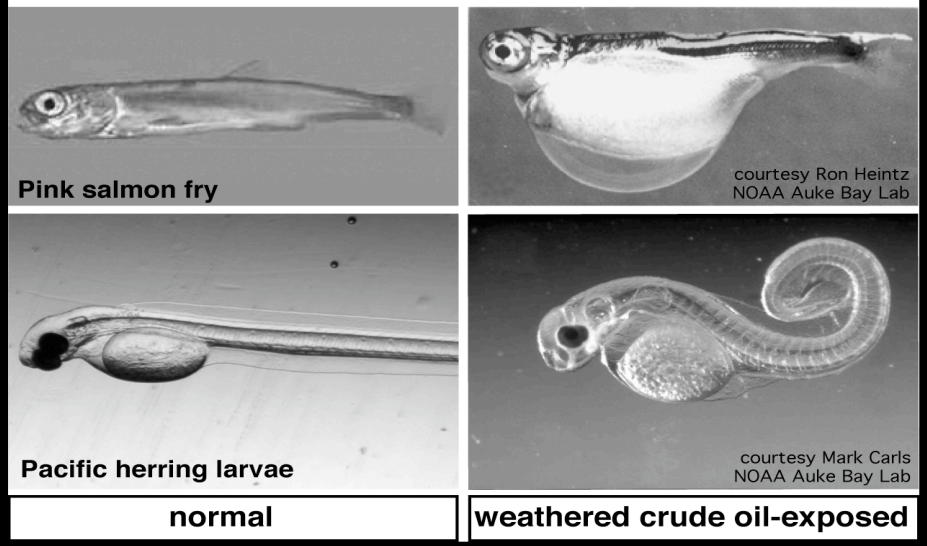
Asterisk denotes significant difference from predicted activity (t-test with a Bonferroni correction, p < .005)

crl = carbaryl
cbn = carbofuran
cfs = chlorpyrifos
dzn = diazinon
mln = malathion

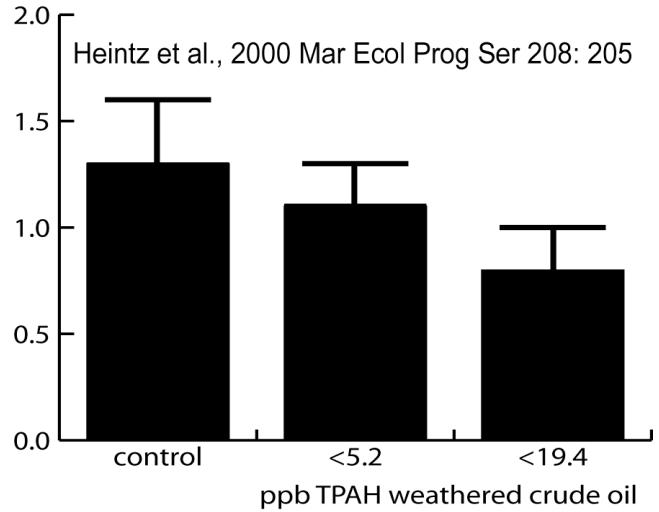
Polycyclic aromatic hydrocarbons in weathered crude oil



Morphological abnormalities resulting from embryonic PAH exposure



Reduced marine survival of morpholgically normal PAH-exposed pink salmon



Sub-lethal effects of toxic contaminants on salmon (or, indirect mortality)

Endpoints with links to survival:

--Olfaction/behavior;
--Swimming speed/feeding behavior/growth;
--Disease resistance;
--Lipid content;

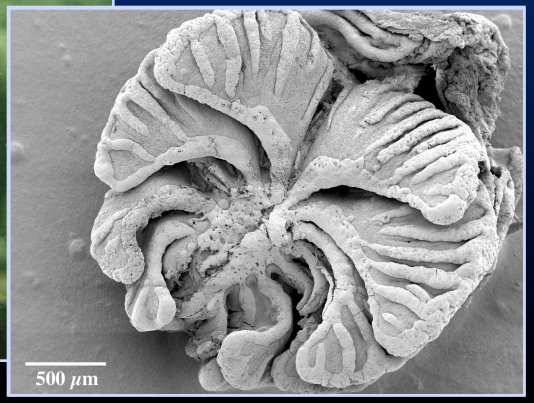
and,

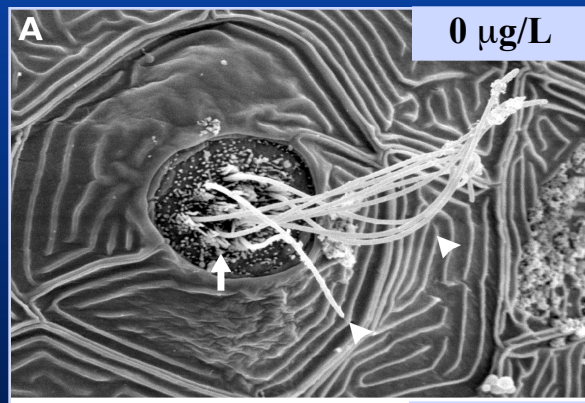
Endocrine disruption (linked to reproductive success)

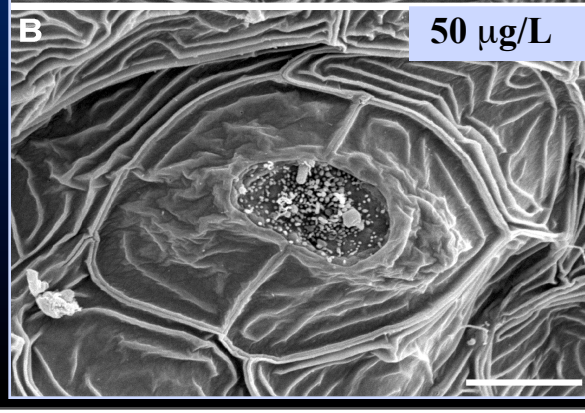
Dissolved copper is toxic to fish sensory systems

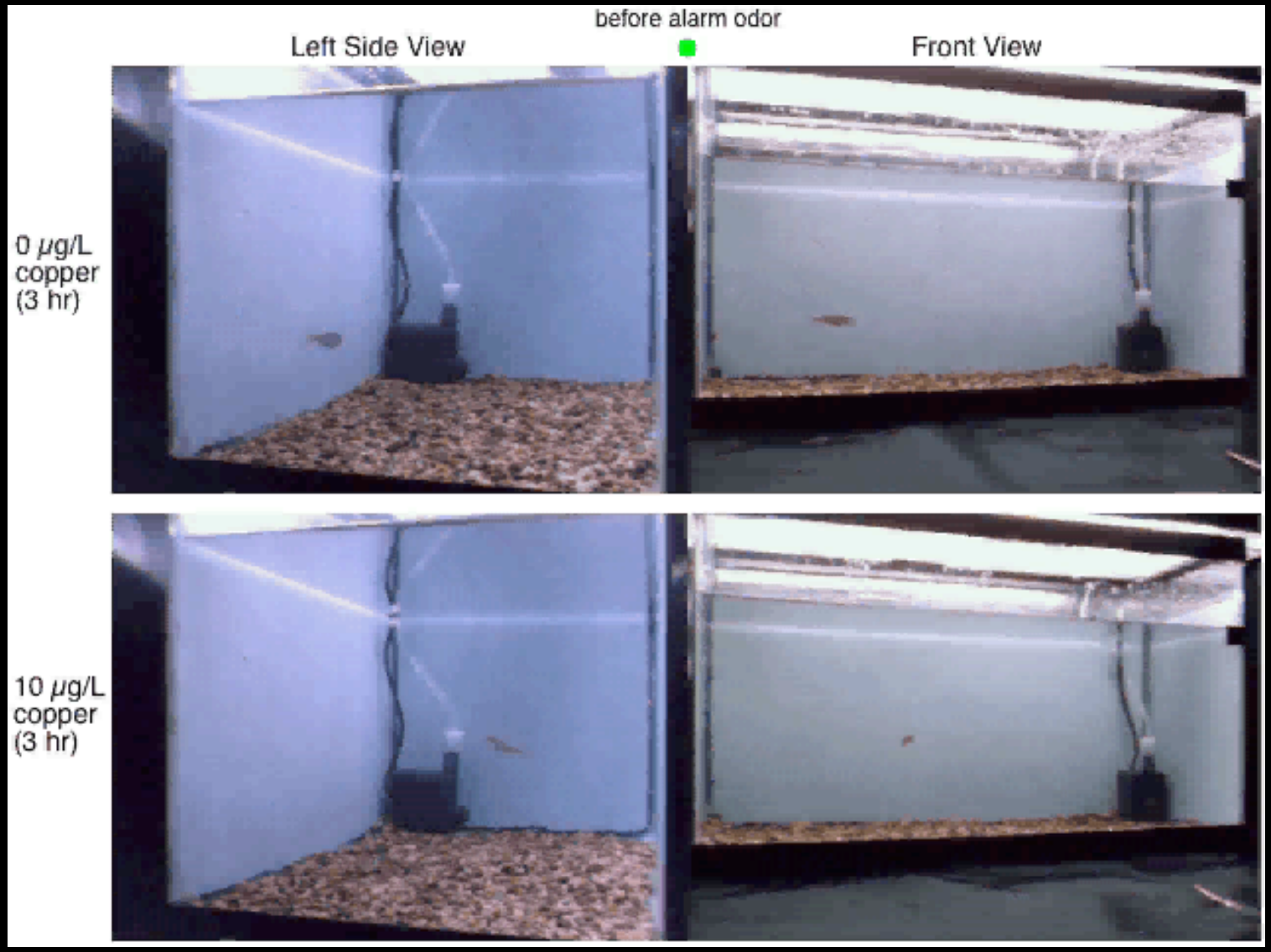
lateral line

nose

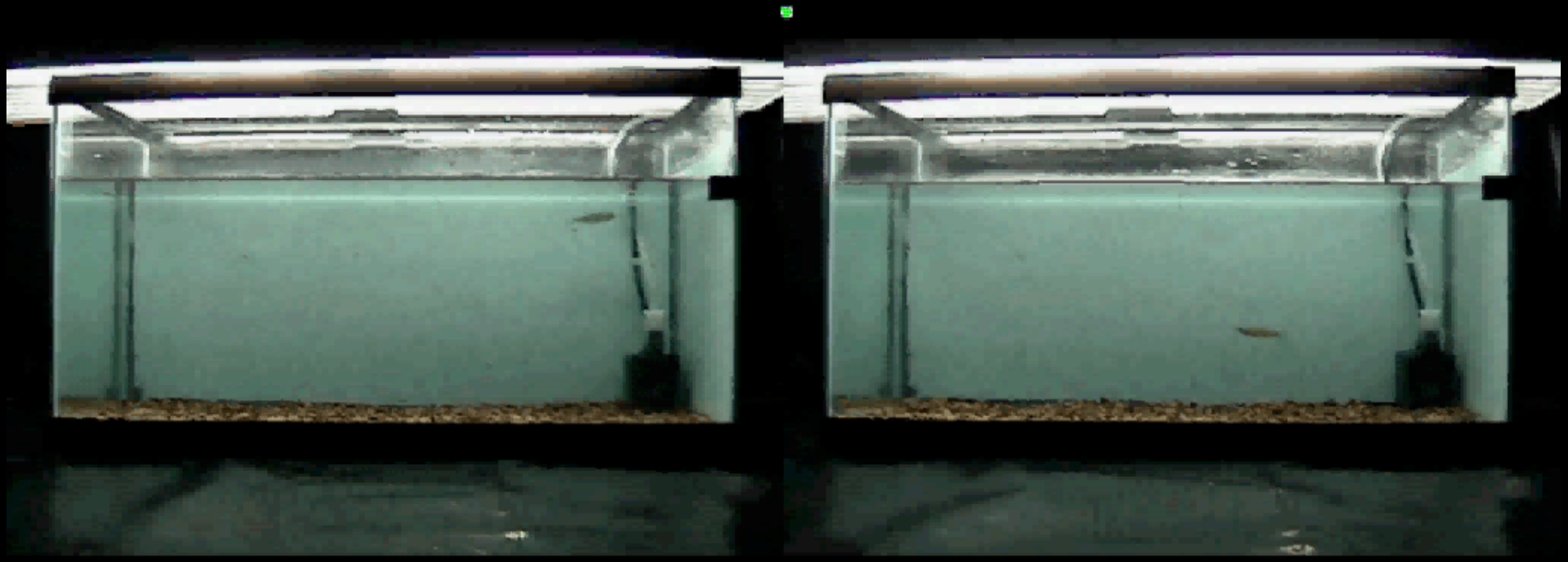







before alarm odor
Left Side View
Front View
0 µg/L copper (3 hr)
10 µg/L copper (3 hr)

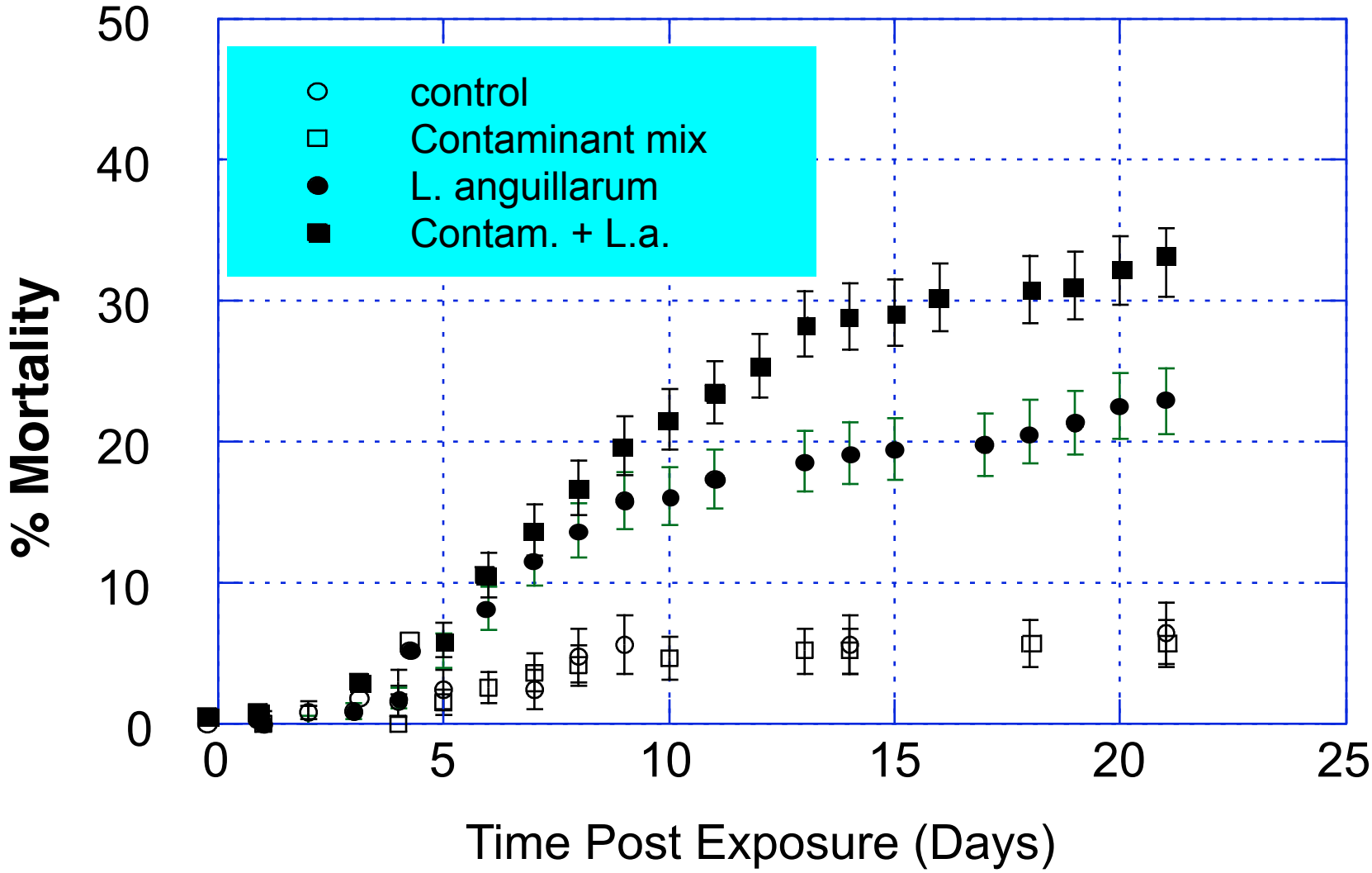
Swimming and feeding behaviors of juvenile coho



control

1.2 µg/L chlorpyrifos
(96 hr)

Increased mortality in chinook salmon fed 'environmentally realistic' dose of PAHs, PCBs, DDTs



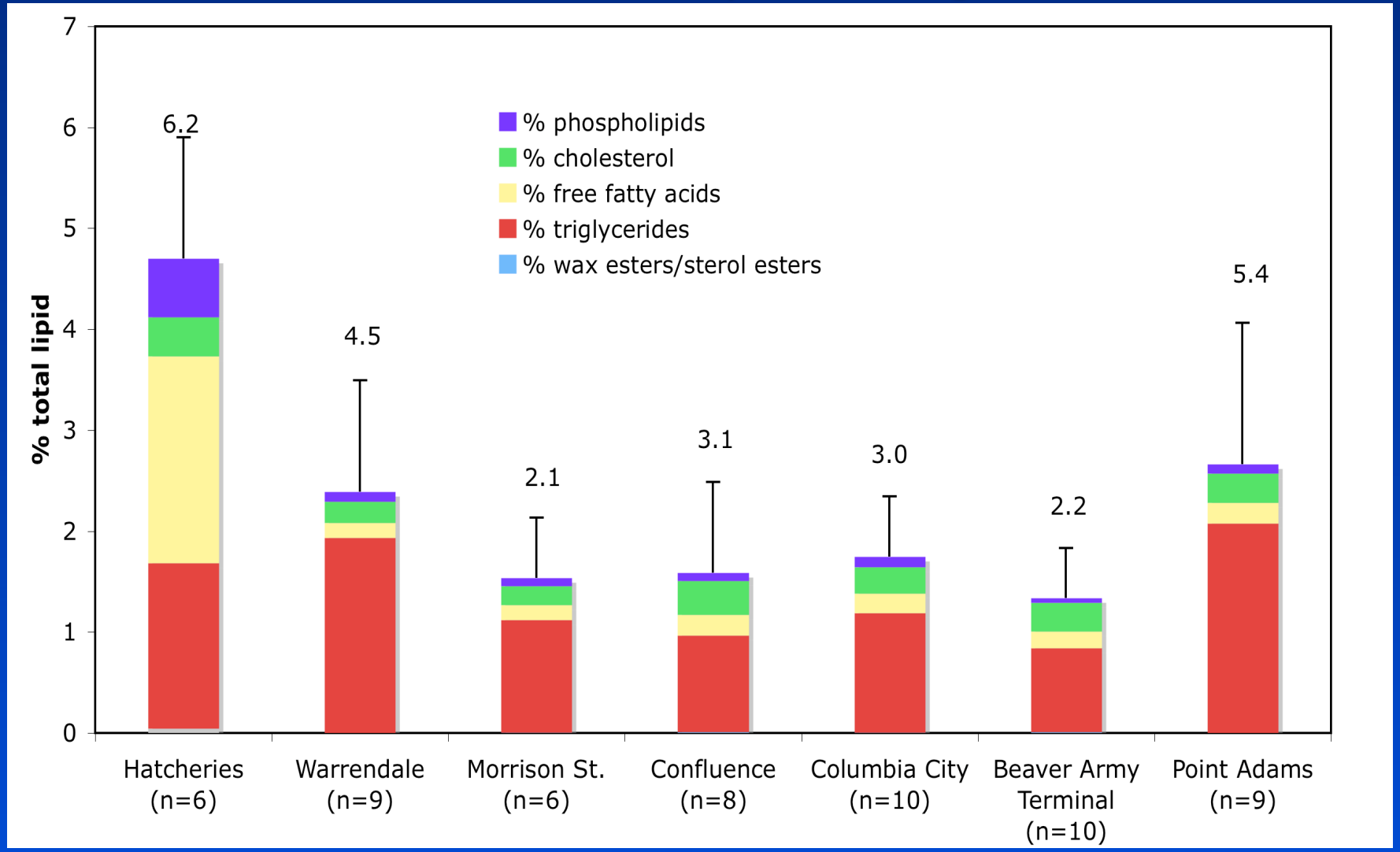
Data from C. Bravo, PhD dissertation, Oregon State U, January 2006

Fish size and lipid content critical for first year survival

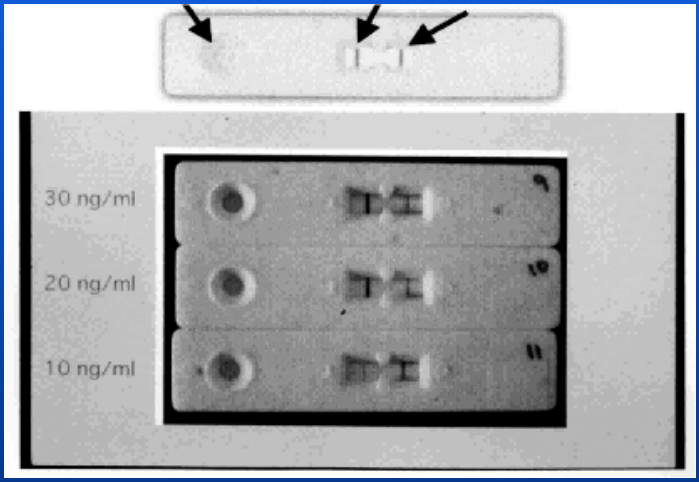
- Biro et al. 2004 determine 1% ww as a critical level for survival of *O. mykiss*

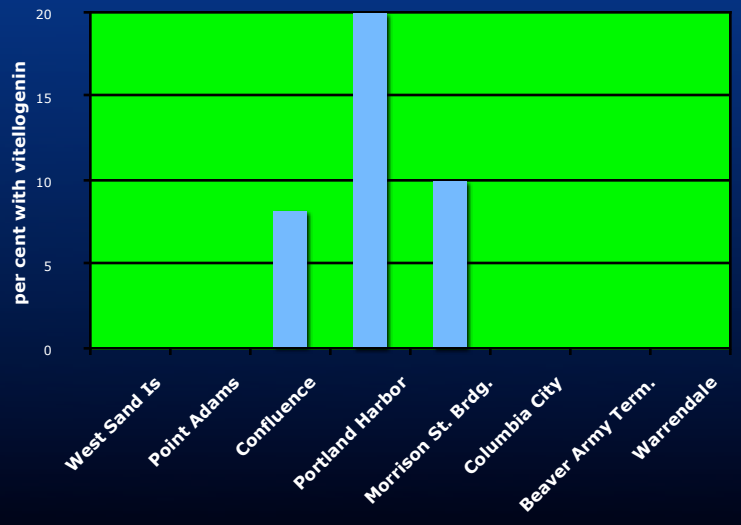
- Meador et al. (2006) demonstrates PAH exposure in diet or water column results in low lipid content, and established PAH exposure levels associated with this type of injury (Meador et al. 2008)

Lipid Classes in field caught salmon
Fish with lowest lipid content are from the same sites where contaminant exposure is greatest



Screening juvenile salmon for exposure to estrogens





Samples collected from fish in the Lower Columbia River and Estuary

Field screening using Best-Checker Vitellogenin test strips (Frontier Science Co Ltd)

Signs of vitellogenin production in 20-30% of salmon from Portland sites

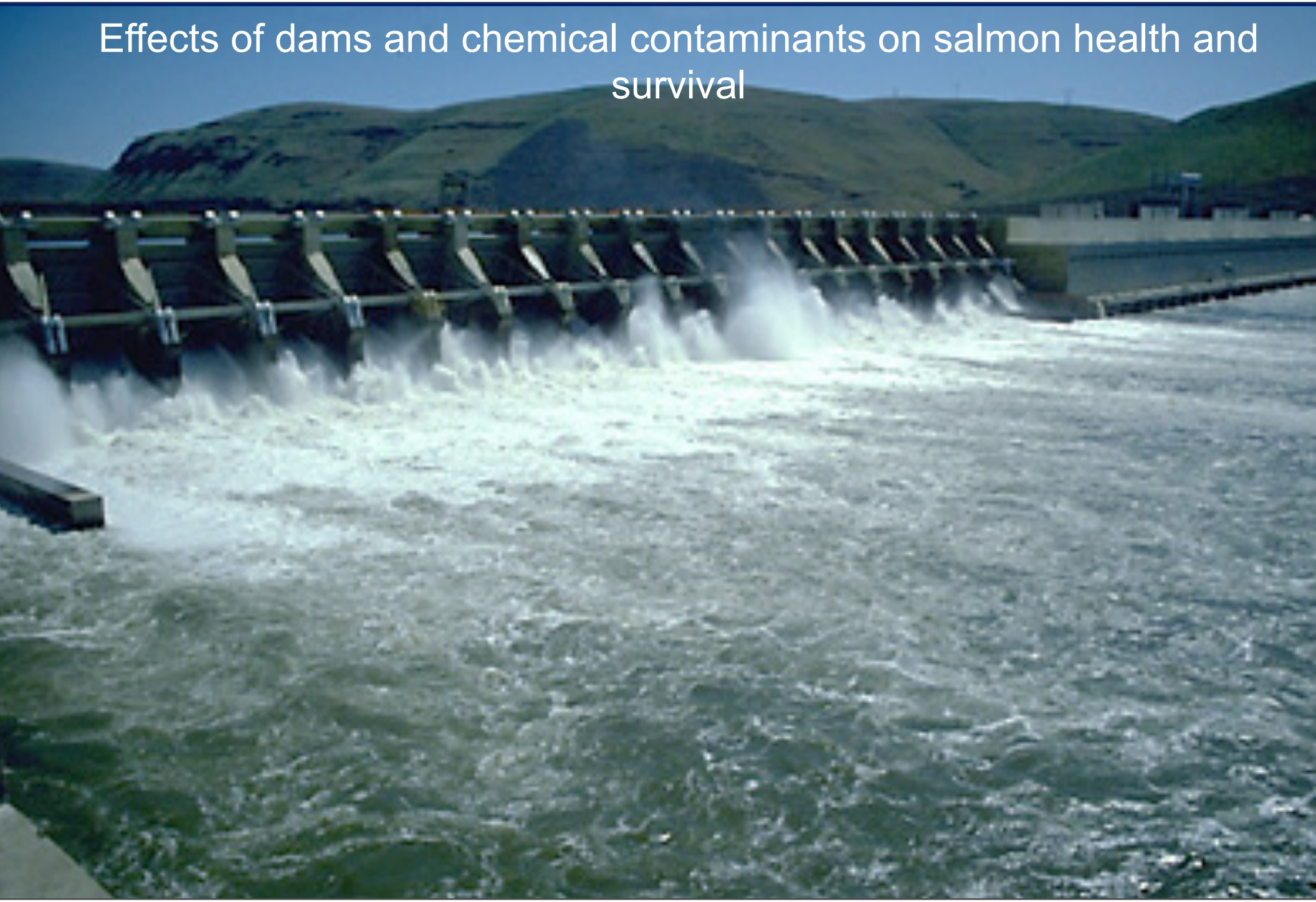
Summary so far . . .

- Contaminant exposure is widespread in juvenile salmonids in the Columbia River, often at levels that approach or exceed health benchmarks.
- There is good potential for lethal effects to be occurring in CR salmonids.
- Sublethal effects, indicative of indirect or delayed mortality, are well documented in juvenile salmonids from the CR.
- Exposure of juveniles does not substantively contribute to body burdens measured in returning adults (not covered today, Q 5).

Estimate of juvenile mortality due to exposure to toxics

Benefits of removing toxics

Effects of dams and chemical contaminants on salmon health and survival



Impacts of environmental stressors on the dynamics of disease transmission (Loge et al. 2005)

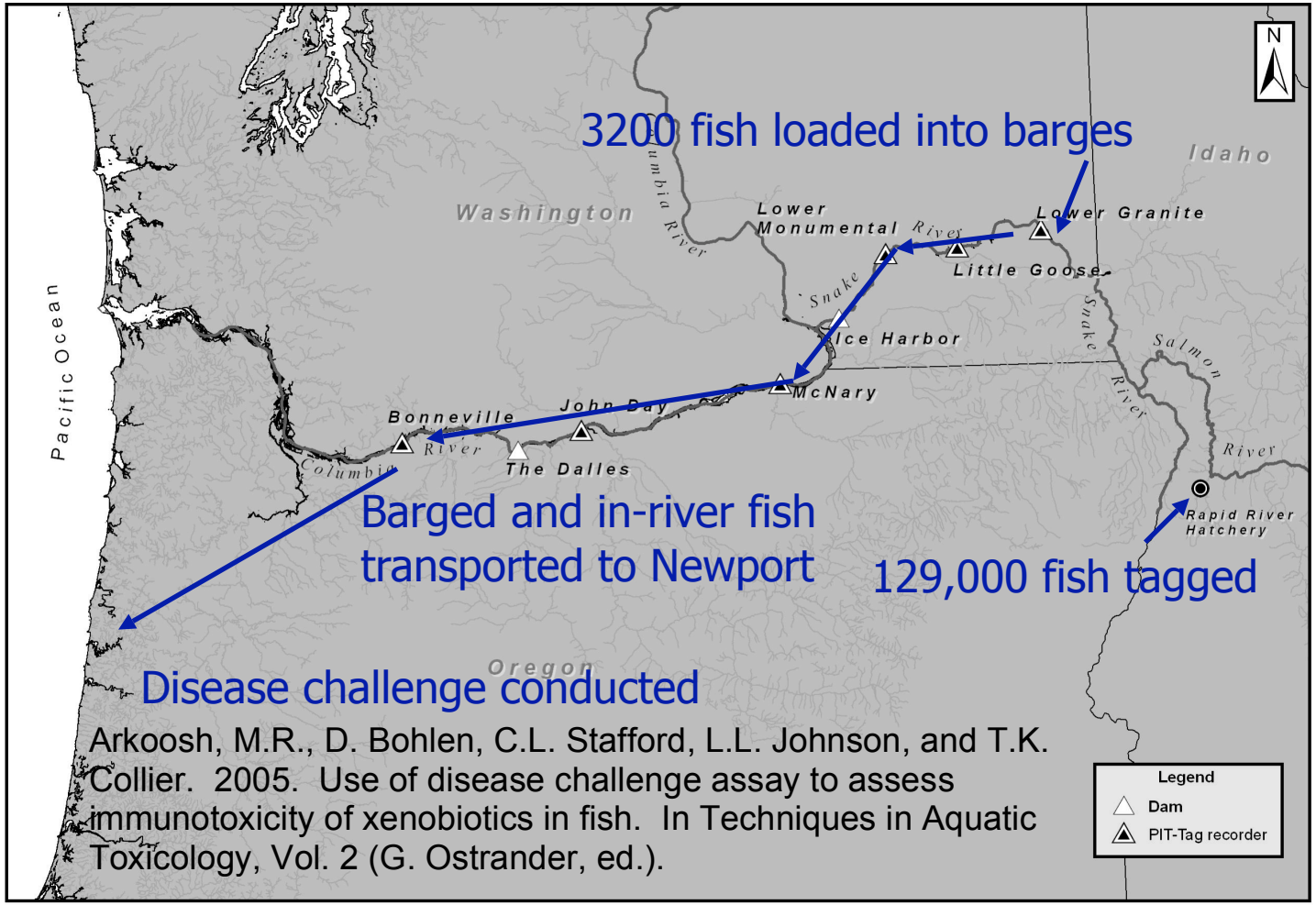
Examines effects of:

- –Stress associated with dam passage
- –Stress associated with contaminant exposure

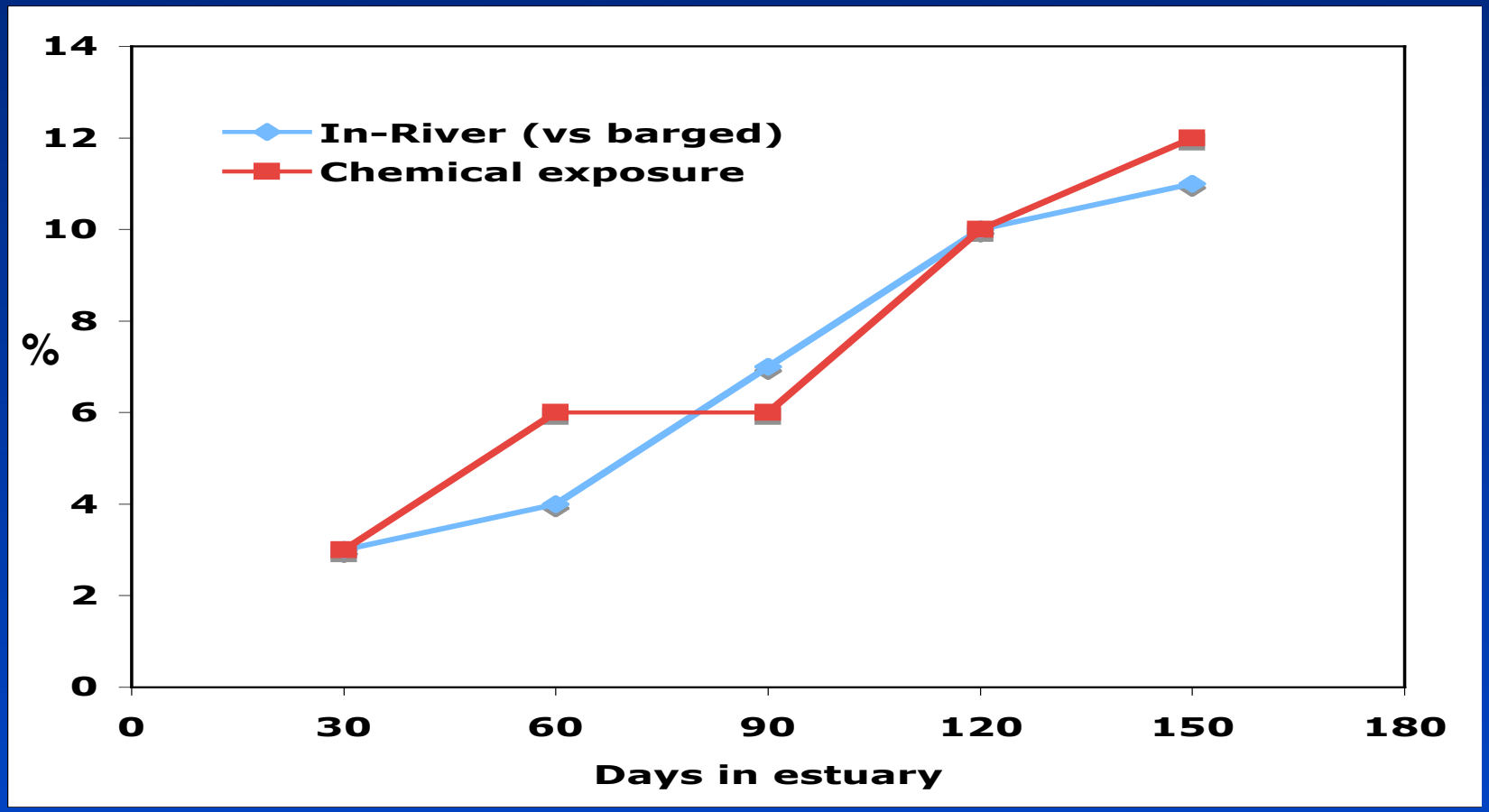
On delayed, disease-induced mortality in juvenile chinook salmon

Mortality estimates come from disease-challenge experiments

Effects of exposure to hydropower system



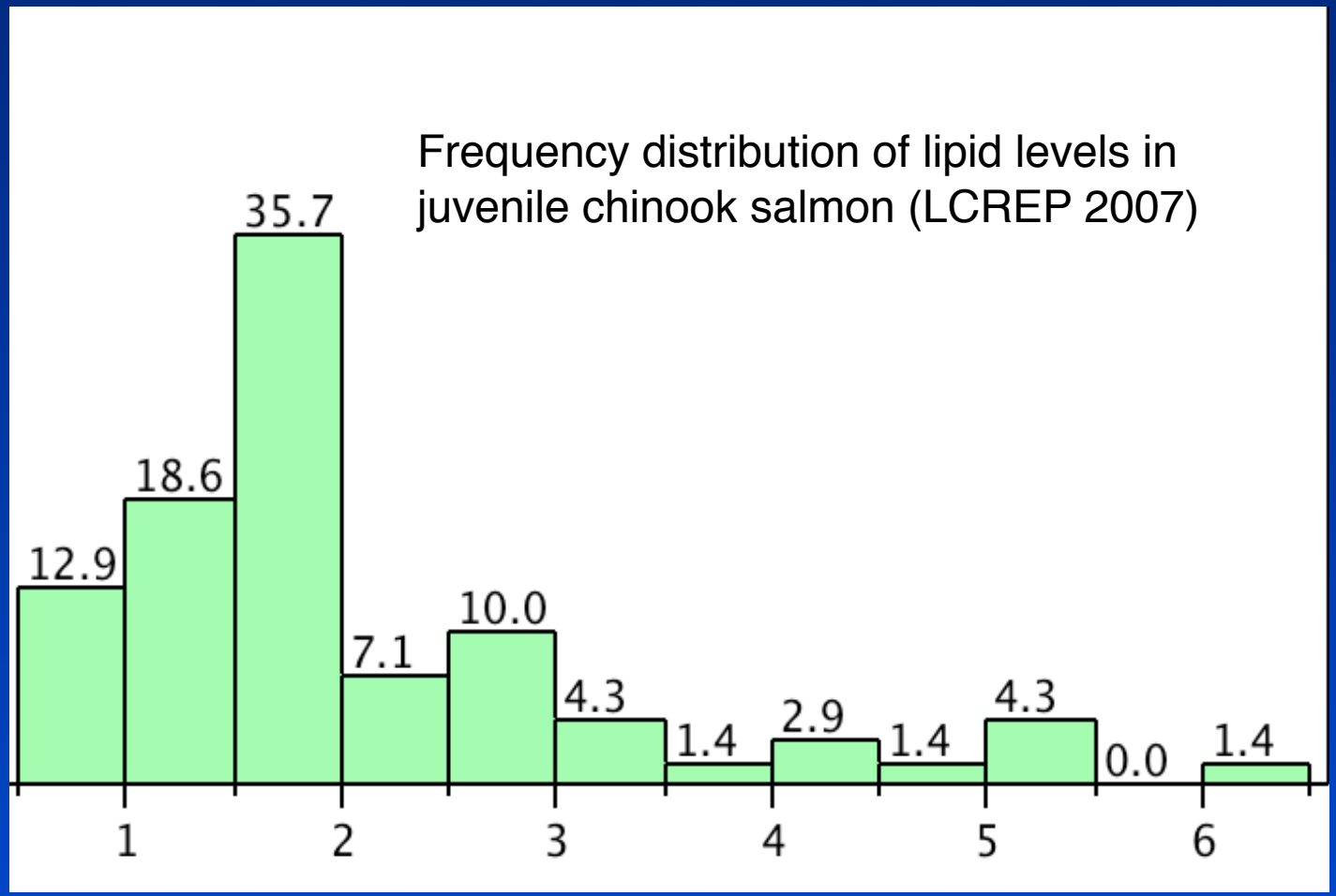
Projected increases in disease-induced mortality during estuary residence



Projected increase in survival needed to mitigate declines is 3-11% (Kareiva et al. 2000).

Loge, F. J., M. R. Arkoosh, T. R. Ginn, L. L. Johnson, and T. K. Collier. 2005. Impacts of environmental stressors on the dynamics of disease transmission. ES&T 39:7329-7336.

Lipid content of LCR juvenile chinook



13% of fish have lipid content ≤ 1%

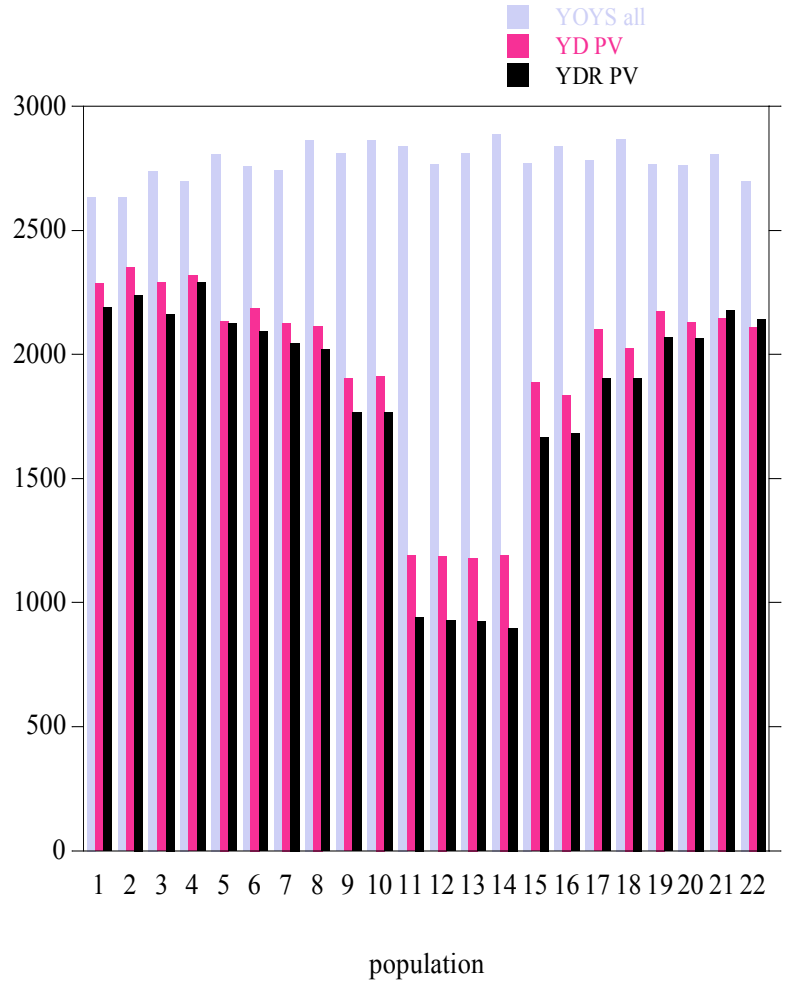
According to Biro et al. 2004, this suggests a potential mortality of ~13%

Potential Effects of Freshwater and Estuarine Contaminant Exposure on Lower Columbia River Chinook Salmon (Oncorhynchus tshawytscha) Populations (Spromberg and Johnson 2008)

- 22 fall chinook salmon populations from Lower Columbia River ESU
- Meta-population model that incorporates straying between populations
- Effects of contaminant-induced changes in survival and fecundity on population size and extinction probability
- Scenarios:
- 20% reduction in YOY survival
- 20% reduction in YOY survival + 10% reduction in ocean survival
- 20% reduction in YOY survival + 10% reduction in ocean survival + 10% reduction in fecundity

Spromberg, J. A., L. L. Johnson. 2008. *in* Akcakaya, H. R., J. D. Stark, T. S. Bridges. (Eds.) Demographic Toxicity Methods in Ecological Risk Assessment. pp.123-142. Oxford University Press, Oxford, United Kingdom.

Lower Columbia River Population Modeling Projections

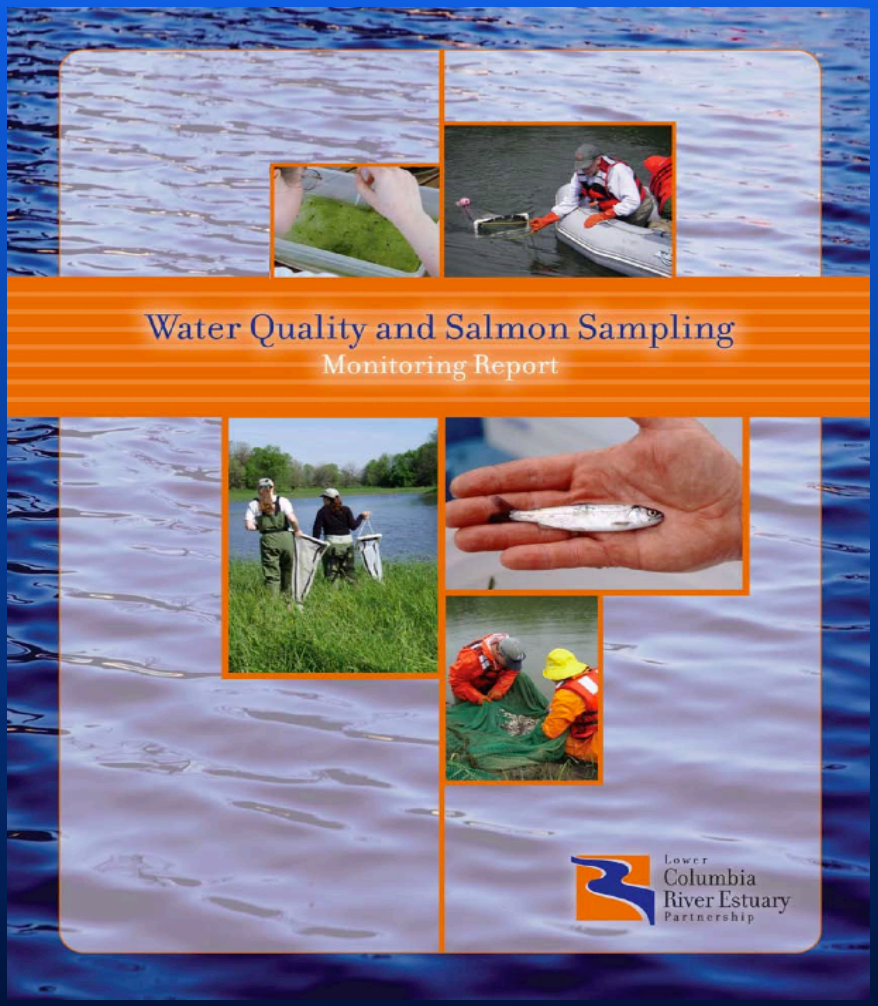


Contaminant-related declines in survival and productivity in populations near Portland and Vancouver alone lead to declines in other Lower Columbia populations connected by straying

Perturbations in populations at contaminant hotspots could influence abundance and population dynamics throughout the ESU

Reasons for concern about toxics . . .

- Contaminants in the Columbia River are affecting the survival and productivity of listed salmon stocks.
- If unaddressed, contaminants may undermine the effectiveness of physical habitat restoration efforts (not discussed today).
- Toxics monitoring and reduction provide a way of mitigating impacts of dam operation that may affect listed salmon through other mechanisms.
- A multi-agency effort to address problems associated with toxics in the Columbia River makes sense if we are serious about salmon recovery.



Lower Columbia River and Estuary Ecosystem and Habitat Restoration Effectiveness Monitoring (LCREP)

Columbia River Toxics Reduction Workgroup (EPA)